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Urban Terrain Building Types, Second Edition
Public Releasable Version

by Richard Ellefsen and David Fordyce

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Urban Terrain Building Types, Second Edition
Public Releasable Version

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14. ABSTRACT

The structure target is a common element of concern to military planners, weaponeers, battle damage assessors, munition designers, firing platform designers, evaluators, modeling and simulation analysts, and developers of suitable range targets for use in live fire and training exercises. Using a precise and comprehensive set of standard geotypical building descriptions as a baseline eliminates a significant variable in estimating weapon effects. To date, a set of building descriptions has not been available to this community. The U.S. Army Research Laboratory, Survivability/Lethality Analysis Directorate, directed the development of this report, which provides these descriptions on a worldwide basis using an established and accepted methodology. This document is an extract of the original ARL technical report (ARL-TR-4395), published in March 2008.

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Authors' Biographies

Richard A. Ellefsen, Ph.D. is a professor emeritus from the San Jose State University. His field of study has been in geography. Dr. Richard Ellefsen is a recognized expert in the areas of urban morphology and city characterization. He has instituted a classification system for urban terrain that is used currently by the U.S. Government. Dr. Ellefsen's work spans a time period of more than 40 years and has numerous publications to his credit. His publications are considered "primary sources."

David Fordyce is a practicing Mechanical Engineer employed by the U.S. Army Research Laboratory Survivability/Lethality Analysis Directorate at APG. Mr. Fordyce has worked for the U.S. Army for 24 years of which 9 have been for ARL. Mr. Fordyce received his B.S.M.E. from the University of Maryland Baltimore County and his M.S.M.E. from the University of Maryland College Park, concentration in Solid Mechanics. Mr. Fordyce has been working on characterizing the urban environment and weapon effects in urban terrain for the past 12 years.

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1. Need

The structure target is a common element of concern to military planners, weaponeers, battle damage assessors, munition designers, firing platform designers, evaluators, modeling and simulation analysts, and developers of suitable range targets for use in live fire and training exercises. Using a precise and comprehensive set of standard geotypical building descriptions as a baseline eliminates a significant variable in estimating weapon effects. To date, a set of building descriptions has not been available to this community. The U.S. Army Research Laboratory, Survivability/Lethality Analysis Directorate, directed the development of this report. This report provides these descriptions on a worldwide basis using an established and accepted methodology.

The first edition of Urban Terrain Building Types was released informally in at a DoD working group meeting held in Vicksburg, MS. The document detailed 40 structure types and regional incidence of occurrence information. During the meeting, a subset of the 40 structure types was chosen by the working group in attendance for developing a more detailed description of the selected structures. The reduced set consists of 14 structure types—7 that have been selected from the mass construction category and 7 from the framed construction category (table 1).

Table 1. Set of 14 structures selected for detail design.

Mass Construction	Framed Construction
Adobe house (UTBT mass 3)	R/C-framed house with brick infill (UTBT framed 12)
Triple brick house (UTBT mass 5)	R/C-framed store/apartment building (UTBT framed 14)
Triple brick Middle Eastern house (UTBT mass 6)	R/C-framed light-clad hotel (UTBT framed 9)
CMU house (UTBT mass 14)	R/C-framed light-clad office (UTBT framed 10)
Box wall apartment (UTBT mass 22)	Central pylon light-clad office (UTBT framed 11)
Box wall hotel (UTBT mass 23)	R/C-framed industrial building with infills (UTBT framed 16)
Brick mosque (UTBT mass 23)	Light steel-framed industrial building with corrugated cladding (UTBT framed 20)

Note: CMU = concrete masonry unit. R/C = reinforced concrete. UTBT = urban terrain building type.

Based on review and input from various DoD organizations, the document was expanded (adding sections on venting, roof characteristics, and 4 additional structures to the original set of 40), made more user-friendly, and submitted to a formal publication process. The second edition of *Urban Terrain Building Types* is the result.

2. Goals

To date, wall and structure target descriptions available for testing and evaluation,[1] analysis, planning, and training[2] are few in type and may not fit within the urban terrain zone (UTZ) methodology. Some of these targets originated in the Cold War of the 1970s and 1980s and do not reflect the current theater of operations. Further, the targets are not standardized across the services, and specifications do not exist for the target construction. The specific goals of this document are as follows:

1. Provide a set of representative geotypical target building types comprising a comprehensive data set of types and specifications that could be encountered in urban operations activities on a global basis, and reflect appropriate regional variation using an established and accepted methodology.
2. Organize the set of target descriptions into a standardized, manageable, readily transferable, and useful form for use by the urban operations community.
3. Provide a comprehensive data set of information on each building type. The data for each building type are:
   a. Building exterior shape and dimensions.
   b. Type of construction method and material characteristics.
   c. Wall composition and thickness (interior and exterior).
   d. Venting character and dimensions (doors and windows).
   e. Interior configurations (room dimensions and room use).
   f. Regional incidence of building-type occurrence (where in the world does the type occur).

3. Approach

Responding to the statement of need and goals discussed earlier, the approach taken was to develop a broad base of information on the physical and functional characteristics of urban terrain building types (UTBTs). Information is organized by primary construction type (mass and framed), specific method of construction and materials used, and details on building

[1]International Test Operating Procedure 5-2-503, Human Engineering Laboratory Technical Memorandum 30-78, STANAG 4536.

[2]McKenna MOUT, Joint Readiness Training Center, and others.

interiors. The building representations and examples in this report are geotypical in nature, i.e., buildings of a common type in a geographical region or structures that are constructed using a common construction method. Usually, these structures are ubiquitous in the geographical area considered. Geospecific building representations describe a particular building in a particular location and are not the subject of this report. A total of 44 UTBTs are presented in the catalog section of the report. This catalog consists of 243 separate plates showing various characteristics and properties. The plates range from 5 to 12 for each building type (the number of plates reflecting levels of complexity).

Several factors were considered when selecting the 44 building types, such as ascertaining that all major worldwide structure types are represented and that the selection met the DoD working group's purpose to present to the broader urban operations community building types that match the interests of a wide variety of users engaged in testing, modeling and simulation, combat development, and weapons/munitions development.

4. Method

The building types presented in this report (see tables 4 and 5) come from canvassing the open literature covering international architecture and structural engineering. Examples of these building types were photographed on numerous field expeditions to 71 cities in 41 countries over an elapsed 50-year period. Many of these photographs serve as examples for users and as the source from which measurements were taken, e.g., venting dimensions. Window patterns also serve as an exterior clue to floor plans. The view of building materials provides valuable keys to construction, e.g., the specific bonding type of brick walls.

Almost all buildings used in the report were photographed by Richard Ellefsen during the course of numerous study trips abroad. Photographs of Koblenz, Germany, were taken by David Fordyce.

Other details, such as floor plans, were taken from occurrences in the literature. Sources used were published books and information from the Web. An especially valuable Internet source is the World Housing Encyclopedia Report (www.world-housing.net) maintained by the Earthquake Engineering Research Institute. Data on building height and spatial placement in an urban setting were derived from open-source aerial photographs and high-resolution satellite data, now available on the Internet for virtually all major urban areas in the world.

An integrated collation of the building types was performed according to the UTZ methodology found in section 13 of this report.

5. Introduction to Tables 2 Through 6

In this report, building types are linked to appearances in UTZ. The UTZ classification system is presented in section 13 of this report. Table 2 provides the urban morphology categories that comprise the UTZ classification system developed by the primary author. The cross-indexing between building types and the UTZ system is presented as table 3. Reference to table 2 and the UTZ plates found in the UTZ methodology section of this report will serve to enhance understanding of both the building types and the UTZs. All but one UTZ plate has an oblique air-photo example (on the right-side panel of each plate). Choosing examples from many cities in the world was a fairly simple task thanks to the universality of the classification system. This serves to confirm that both the cause and the response to urban/economic/social stimuli are universal, even when countries vary widely in their form of government. (For example, the People's Republic of China's approach in their large cities does not differ from capitalistic countries.)

Tables 4–6 form an integral trio. Tables 4 and 5 serve the purpose of providing an index (see page numbers in the right column referring to the plate location for each building type in the catalog). These two tables indicate the primary type of construction (mass or framed), the more specific methods of construction (e.g., unit masonry), and the discrete type of building material of which each building type is made (e.g., kiln-dried brick). That some groups have more entries than others expresses the incidence of building-type occurrence on a global basis. For instance, only two entries are listed for stone buildings, as such structures are uncommon (at least, all-stone structures as opposed to those with a stone veneer over other forms of construction). Kiln-dried brick construction and various forms of infill wall associated with framed buildings have nine and eight entries, reflecting their broad worldwide occurrence.

Table 2. Current UTZ classification system.

Attached Buildings UTZs		**Detached, Closely Spaced Buildings UTZs**		**Detached, Widely Spaced Buildings UTZs**	
A1	Attached commercial buildings	Dc1	Detached, closely spaced high-rise office buildings	Do1	Shopping centers with parking lots
A2	Attached hotels and apartment buildings	Dc2	Detached, closely spaced apartment buildings	Do2	Detached, widely spaced apartment buildings
A3	Attached houses	Dc3	Detached, closely spaced houses	Do3	Detached, widely spaced houses
A4	Attached industrial /storage buildings	Dc4	Detached, closely spaced industrial/storage buildings	Do4	Detached, widely spaced industrial/storage buildings
A5	Attached commercial buildings along arterial streets	Dc5	Detached, closely spaced commercial buildings	Do5	Detached, widely spaced commercial buildings
—	—	Dc6	Detached, closely spaced administrative/cultural buildings	Do6	Detached, widely spaced administrative/cultural buildings

Note: UTZ = urban terrain zone.

Table 3. Common locales by UTZs for building types.

Target Type (UTBT Designation)	Urban Terrain Building Type	UTZs Where Type Is Common
Mass 1-1	Stone house	Old A1
Mass 2-1	Stone institutional	A1
Mass 3-1	Adobe house	Developing Nation A3
Mass 4-1	Mud brick single-floor store	Developing Nation A1
Mass 5-1	Triple brick house	A3, Dc3
Mass 6-1	Triple brick Middle Eastern house	A3, Dc3
Mass 7-1	Brick row house	A3
Mass 8-1	Brick apartment building	A2, Dc2
Mass 9-1	Brick hotel	A1, A2
Mass 10-1	Brick office	A1
Mass 11-1	Brick store	A1, A5
Mass 12-1	Brick mosque	A1, A3, Dc3, Dc6, Do6
Mass 13-1	Brick industrial/storage	A4, Dc4
Mass 14-1	CMU house	Dc3, Do3
Mass 15-1	CMU store	A5, Dc5
Mass 16-1	CMU industrial/storage	Dc4, Do4
Mass 17-1	Brick-over-block house	A3, Dc3, Do3
Mass 18-1	German brick-over-block house	A3, Dc3, Do3
Mass 19-1	Unreinforced apartment with masonry cover	A2
Mass 20-1	Retail store	A1, Dc5, Do1, Do5
Mass 21-1	Tilt-up industrial/storage	Do4
Mass 22-1	Box-wall apartment building	Do2
Mass 23-1	Box-wall hotel	A1, A2, Do5
Framed 1-1	Half-timbered wood house	A1, A3
Framed 2-1	Half-timbered wood store	A1, A5
Framed 3-1	Wood-framed house	Dc3, Do3
Framed 4-1	Brick veneer house	Dc3, Do3
Framed 5-1	Wood-framed store	A5, Dc5
Framed 6-1	Heavy-clad hotel	A1, Dc1, Do1
Framed 7-1	Heavy-clad office	A1, Dc1, Do1
Framed 8-1	Light-clad apartment building	Do2
Framed 9-1	Light-clad hotel	A1, Dc1, Do1
Framed 10-1	Light-clad office	A1, Dc1, Do1
Framed 11-1	Central pylon office building	Dc1, Do1
Framed 12-1	Brick infill house	A3, Dc3
Framed 13-1	Terra cotta infill house	A3, Dc3
Framed 14-1	Store/apartment	A5, Dc5
Framed 15-1	Brick infill store/office	A5, Dc5
Framed 16-1	Industrial/storage with CMU infill	A4, Dc4, Do4
Framed 17-1	Industrial/storage with terra cotta infill	A4, Dc4, Do4
Framed 18-1	Industrial/storage with brick infill	A4, Dc4, Do4
Framed 19-1	School with brick infill	Do6
Framed 20-1	Light steel-framed industrial storage	Dc4, Do4
Framed 21-1	Light steel-framed double-industrial storage	Dc4, Do4
44 Total Types		

Note: UTBT = urban terrain building type. UTZ = urban terrain zone.

Table 4. Forty-four universal UTBTs by method of mass construction and by function.

Table of Structures and Index to Building Types						
Principal Construction Method	**Sub Type**	**Building Material**	**Function**	**UTBT Title**	**UTBT I.D. No.**	**UTBT Page No.**
Mass construction	Buildings that use masonry units	Stone	Residential	Stone house	Mass 1	50
			Institutional	Stone institutional	Mass 2	55
		Sun-dried mud brick (adobe)	Residential	Adobe house	Mass 3	61
			Retail	Single floor store	Mass 4	68
		Kiln-fired brick	Residential	Triple brick house	Mass 5	76
				Middle Eastern house	Mass 6	84
				Row house	Mass 7	92
				Brick apartment building	Mass 8	100
			Hotel	Brick hotel	Mass 9	106
			Office	Brick office	Mass 10	111
			Store	Brick store	Mass 11	117
			Institutional	Brick mosque	Mass 12	122
			Industrial	Industrial/storage	Mass 13	127
		CMU	Residential	CMU house	Mass 14	132
			Retail	CMU store	Mass 15	138
			Industrial	CMU industrial/storage	Mass 16	143
		Brick over block	Residential	Brick over block	Mass 17	148
				German brick over block	Mass 18	153
	Concrete	Poured in place	Residential	Unreinforced apartment with masonry cover	Mass 19	160
			Retail	Retail store	Mass 20	166
		Tilt-up	Industrial	Industrial/storage	Mass 21	171
		Box-wall principle (panel)	Residential	Apartment building	Mass 22	177
			Hotel	Hotel	Mass 23	189

Note: UTBT = urban terrain building type. CMU = concrete masonry unit.

The function column gives the use of each building type, in systematic order, beginning with residential (houses and apartment buildings) and followed by hotels, offices, retail stores, institutional buildings, and industrial/storage buildings. These general classes are in accord with the widely accepted land-use classes seen in such U.S. government documents as the *Standard Land Use Coding Manual*.

Table 6 expands upon the entries in tables 4 and 5. It is designed to provide users with a quick, comprehensive reference guide to a variety of physical UTBT properties covered in this report. For each building type, data are provided on wall dimensions and materials; floors; roof sizes and materials; venting; and room dimensions. All of these data items refer to and are derived from detailed data presented in the 243 plates (for 44 distinctive UTBTs) in the catalog.

Table 5. Forty-four universal UTBTs by method of framed construction and by function.

Table of Structures and Index to Building Types						
Principal Construction Method	**Sub Type**	**Building Material**	**Function**	**UTBT Title**	**UTBT I.D. No.**	**UTBT Page No.**
Framed construction	Wood post and lintel	Half-timbered	Residential	House	Framed 1	196
			Retail	Store	Framed 2	201
		Light wood frame	Residential	Wood-framed house	Framed 3	207
				Brick veneer house	Framed 4	214
			Retail	Store	Framed 5	219
	Steel or R/C frame	Steel-framed heavy clad	Hotel	Hotel	Framed 6	224
			Office	Office	Framed 7	233
		Steel- or R/C-framed light clad	Residential	Apartment building	Framed 8	243
			Hotel	Hotel	Framed 9	248
			Office	Office	Framed 10	257
			Central pylon office	Office	Framed 11	263
		R/C-framed with infill walls	Residential	Brick infill house	Framed 12	270
				Terra cotta infill house	Framed 13	282
			Mixed residential /commercial	Store/apartment	Framed 14	290
			Retail	Brick infill store/office	Framed 15	298
			Industrial	Industrial/storage with CMU infill	Framed 16	303
				Industrial/storage with terra cotta infill	Framed 17	309
				Industrial/storage with brick infill	Framed 18	315
			Institutional	School with brick infill walls	Framed 19	321
		Very light steel framed	Industrial	Industrial/storage	Framed 20	327
				Double industrial/storage	Framed 21	332

Note: UTBT = urban terrain building type. R/C = reinforced concrete. CMU = concrete masonry unit.

Table 6. Building properties table.

Building Type Mass Construction	Building I.D.	Location	External Wall Thick. (cm)	External Wall Masonry Unit Size (cm)	Interior Wall Thick. (cm)	Interior Wall Masonry Unit Size (cm)	Interior Wall Material	Floor Material	Roof Shape	Roof Material	Roof Thick. (cm)	Mean Percent Window Front Wall	Mean Percent Doors Front Wall	Mean Window Size (m^2)	Mean Room Size (m^2)
Stone house	Mass 1	Europe	40	Varied	20	Varied	Stone	Wood	Pitched	Tile	2	7.8	4.1	1.2	16.0
Stone institutional building	Mass 2	Europe	40–100	Varied	Varied	Varied	Stone	Stone	Pitched	Tile	4	10.3	6.2	2.2	125.0
Adobe house	Mass 3	Southwest Asia	80	40 × 26	80	40 × 26	Adobe	Adobe	Flat/domed	Mud/wattle	10	7.8	5.9	1.2	19.8
Adobe store	Mass 4	Southwest Asia	48	30 × 15	48	30 × 15	Adobe	Adobe	Flat	Mud/wattle	10	6.9	6.2	1.9	40.0
Triple brick house	Mass 5	World	36	11.5 × 23	23	11.5 × 23	Brick	Wood	Pitched	Tile	2	13.3	6.9	1.2	12.7
Middle Eastern house	Mass 6	SWA	34.5	11 × 22	34.5	11 × 22	Brick	Concrete	Flat	Concrete	10	0.0	6.2	0.0	24.8
Row house	Mass 7	World	36	11.5 × 23	23	11.5 × 23	Brick	Wood	Pitched	Tile	2	12.1	6.9	2.4	17.7
Brick apartment building	Mass 8	World	48–96	11.5 × 23	23	11.5 × 23	Brick	Wood	Pitched	Tile	2	13.1	10.5	2.4	19.3
Brick hotel	Mass 9	World	48–96	11.5 × 23	23	11.5 × 23	Brick	Wood	Pitched	Tile	2	16.4	11.8	1.9	17.8
Brick office	Mass 10	World	48–96	11.5 × 23	23	11.5 × 23	Brick	Wood	Pitched	Tile	2	15.0	2.6	2.1	26.7
Brick store	Mass 11	World	36	11.5 × 23	23	11.5 × 23	Brick	Wood	Pitched	Tile	2	20.8	20.8	1.9	20.0
Brick mosque	Mass 12	Southwest Asia	60	11.5 × 23	None	NA	NA	Tile	Flat/domed	Brick	10	6.3	1.1	NA	125.0
Brick industrial/storage	Mass 13	World	36	11.5 × 23	23	11.5 × 23	Brick	Concrete	Pitched	Tile	2	18.1	2.6	3.8	360.0
CMU house	Mass 14	World	20	20 × 40	10	10 × 40	CMU	Concrete	Pitched	Tile	2	10.1	7.5	1.2	11.2
CMU store	Mass 15	World	20	20 × 40	20	20 × 40	CMU	Concrete	Pitched	Composite	1	48.7	25.5	1.9	16.0
CMU industrial/storage	Mass 16	World	20	20 × 40	10	10 × 40	CMU	Concrete	Pitched	Steel	0.2	18.1	2.6	1.5	78.5
Brick/block house	Mass 17	North America	32.5	Combination[a]	20	20 × 40	CMU	Concrete	Pitched	Tile	2	13.3	6.4	1.2	13.3
German brick/block house	Mass 18	Europe	35.5	Combination[b]	23	23 × 46	CMU	Concrete	Pitched	Tile	2	13.3	5.6	1.2	15.5
Concrete apartment	Mass 19	Southwest Asia	45	Combination[c]	15	NA	Concrete	Concrete	Flat	Concrete	10	13.1	10.5	2.4	13.5
Concrete store	Mass 20	World	20	Non unit	10	Stud	Steel/wood	Concrete	Flat	Concrete	10	16.3	7.5	1.9	504.0
Tilt-up industrial	Mass 21	North America	20	Non unit	10	Stud	Steel/wood	Concrete	Flat	Concrete	10	5.4	13	3.8	280.0
Box wall apartment	Mass 22	Europe	20	Non unit	16	NA	Concrete	Concrete	Flat	Concrete	10	24.2	2.4	3.0	16.3
Box wall hotel	Mass 23	North America	15	Non unit	15	NA	Concrete	Concrete	Flat	Concrete	10	39.4	1.1	4.0	28.0

[a]Combination: CMU block (20 cm) and brick (11.5 cm). [b]Combination: CMU (German, 25 cm) and brick (11.5 cm). [c]Combination: poured concrete (30 cm) plus stone (15 cm).
NA = not applicable.

Table 6. Building properties table (continued).

Building Type Mass Construction	Building I.D.	Location	External Wall Thick. (cm)	External Wall Masonry Unit Size (cm)	Interior Wall Thick. (cm)	Interior Wall Masonry Unit Size (cm)	Interior Wall Material	Floor Material	Roof Shape	Roof Material	Roof Thick. (cm)	Mean Percent Window Front Wall	Mean Percent Doors Front Wall	Mean Window Size (m^2)	Mean Room Size (m^2)
Half-timbered house	Framed 1	Europe	15	Non unit	15	Stud	Wood	Wood	Pitched	Tile	2	9.1	2.4	1.9	18.2
Half-timbered store	Framed 2	Europe	15	Non unit	15	Stud	Wood	Wood	Pitched	Tile	2	12.0	5.1	1.9	32.0
Wood-framed house	Framed 3	Regional	14–24	Non unit	12	Stud	Wood	Wood	Pitched	Tile	2	9.1	10.5	1.9	14.3
Brick veneer house	Framed 4	Regional	24	11.5 × 23	12	Stud	Wood	Wood	Pitched	Tile	2	9.1	10.5	1.9	14.3
Wood store	Framed 5	Regional	12	Non unit	12	Stud	Wood	Wood	Pitched	Tile	2	0.0	70	0.0	30.0
Steel-framed hotel	Framed 6	World	35.5	Non unit	12	Stud	Steel/wood	Concrete	Flat	Concrete	10	18.3	2.8	2.4	21.6
Steel-framed office	Framed 7	World	35.5	Non unit	12	Stud	Steel/wood	Concrete	Flat	Concrete	10	17.6	0.8	24.4	74.2
Light clad apt	Framed 8	World	2–5	Non unit	12	Stud	Steel/wood	Concrete	Flat	Concrete	10	21.9	0.6	2.7	16.2
Light clad hotel	Framed 9	World	2–5	Non unit	12	Stud	Steel/wood	Concrete	Flat	Concrete	10	23.9	1.3	2.4	28.0
Light clad office	Framed 10	World	2–5	Non unit	12	Stud	Steel/wood	Concrete	Flat	Concrete	10	33.7	0.6	26.7	112.0
Central pylon office	Framed 11	World	2–5	Non unit	12	Stud	Steel/wood	Concrete	Flat	Concrete	10	33.7	0.8	26.7	264.0
Brick infill house	Framed 12	World	23	11.5 × 23	11.5	11.5 × 23	Brick	Concrete	Flat	Concrete	10	13.9	2.9	1.9	11.6
Terra cotta infill house	Framed 13	World	25	25 × 40	11.5	11.5 × 23	Brick	Concrete	Flat	Concrete	10	10.1	2.9	1.9	11.6
CMU infill store/apartment	Framed 14	World	20	20 × 40	10	10 × 20	CMU	Concrete	Flat	Concrete	10	13.4	3	2.7	40.0
Brick infill store	Framed 15	World	23	11.5 × 23	12	Stud	Steel/wood	Wood	Flat	Concrete	10	20.8	1.8	3.6	27.0
CMU infill industrial/storage	Framed 16	World	20	20 × 40	20	20 × 40	CMU	Concrete	Pitched	Steel	0.2	2.5	9.1	2.0	592.0
Terra cotta infill industrial/storage	Framed 17	World	25	25 × 40	12	Stud	Steel	Concrete	Pitched	Steel	0.2	2.5	9.1	2.0	592.0
Brick infill industrial/storage	Framed 18	World	23	11.5 × 23	12	Stud	Steel/wood	Wood	Flat	Concrete	10	2.5	9.1	2.0	592.0
Brick infill school	Framed 19	World	23	11.5 × 23	12	Stud	Steel/wood	Concrete	Flat	Concrete	10	20.9	0.7	11.5	68.6
Light-framed industrial/storage	Framed 20	World	0.2	Non unit	None	Stud	Steel/wood	Concrete	Pitched	Steel	0.2	4.4	7.4	8.0	105.0
Double light-framed industrial/storage	Framed 21	World	0.2	Non unit	None	Stud	Steel/wood	Concrete	Pitched	Steel	0.2	4.4	5.7	2.5	950.0

Note: 12 cm includes air space between studs. Non unit: wall not composed of masonry units. Regional: Northwest Europe, North America, Japan, tropics.

6. An Overview of the UTBT Catalog by Method of Construction and by Function

The UTBT catalog is organized based on a melding of both morphology (the physical characteristics of buildings) and function (a building's use). Knowledge of both are essential to urban operations in order to know the arrangement, shape, and dimensions of a building's interior as well as its setting in the urban environment.

Morphology is more important than function considering that the battlefield's physical aspects at the beginning of urban operations during a conflict far outweigh the building's functions prior to the start of the conflict. Here, emphasis on morphology is intended to counter the literature's often overly generalized focus on function alone, e.g., industry, retail, or residential.

While the broader term "urban morphology" comprises all physical aspects of a city (ranging from street dimensions, pattern, and trafficability to other non-built-upon surface space, buildings, and monuments), this document focuses on the morphology of buildings.

The primary forms of building construction are mass and framed. A major distinction is made between mass construction—where walls have to be stout as they need to bear both live and dead loads of walls, floors, and roof—and framed construction where it is the frame that bears all loads, allowing walls to be thin and lightweight. Figure 1 is used here to provide a basic organization of building construction types.

For mass construction, the primary components are unit masonry and concrete. The former refers to walls built with units, i.e., stone, adobe, brick, and CMUs. Concrete walls are made by pouring the material into forms where it hardens into walls and other shapes. A CMU wall, when grout fills cavities in the blocks, is, in effect, a concrete wall.

Framed construction differences are based on the type of frame being employed, e.g., wood, steel, or reinforced concrete. The catalog outlines both frame materials and configuration, and cladding- and infill-material characteristics.

There are some exceptions to the generalized construction types listed in figure 1 whose emphasis is on wall vulnerability. Construction of some buildings employs features of both mass and framed construction. Commonly seen forms of construction are (1) use of a mass construction foundation on which sits a framed structure (figure 2); (2) a mass-construction (reinforced concrete) end wall of a high-rise steel-framed building (figure 3); (3) a shear wall in the basement of a framed structure (figure 4); and (4) a wood-framed building resting on a reinforced concrete base (figure 5). Another example is the central pylon type of construction for some high-rise framed buildings (see section 12, framed 11-1) which uses a mass construction reinforced-concrete central unit (a pylon) onto which frame members are attached.

An everyday U.S. example is that of a wood-framed house or other small building supported by a concrete perimeter foundation.

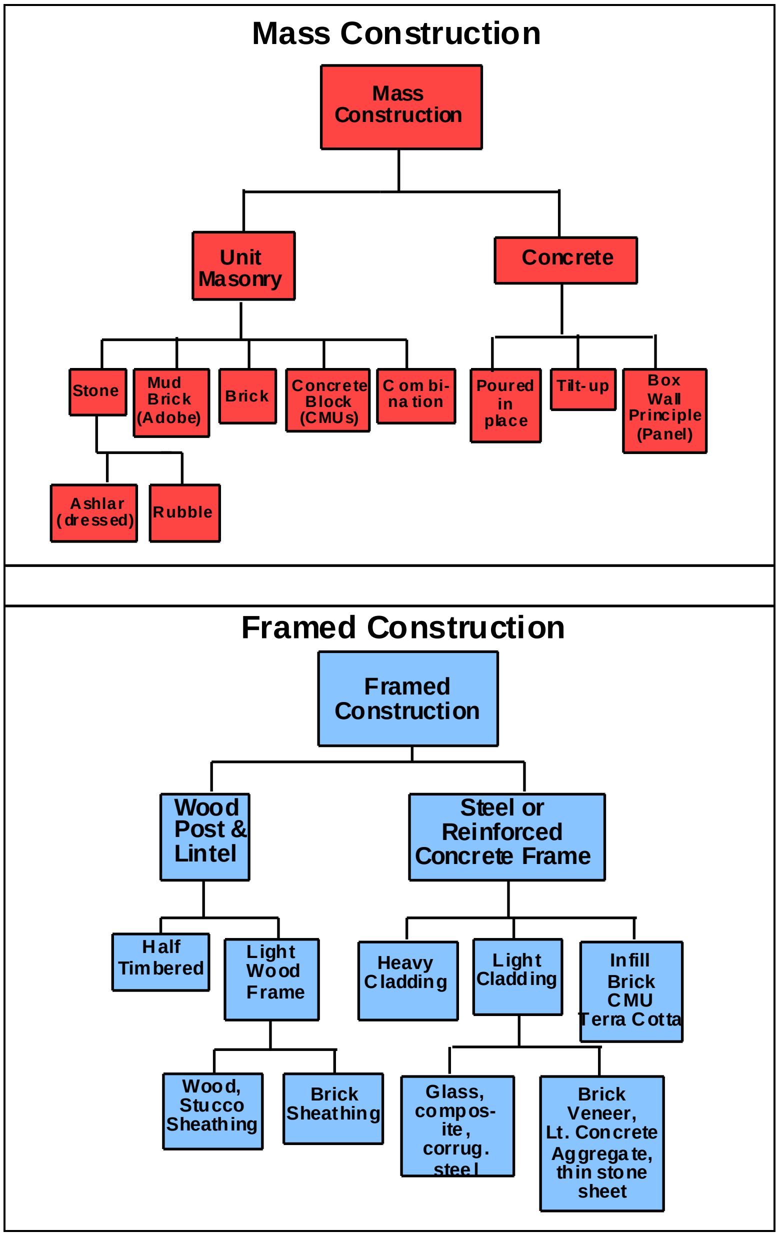

Figure 1. Mass construction (red) is intended to imply buildings that have walls that bear significant weight (both dead and live loads), i.e., "load-bearing walls." Framed construction (blue) indicates structures in which a frame carries the required loads.

Figure 2. A half-timbered frame house resting on a stone ground floor.

Figure 3. The reinforced concrete end wall of a steel-framed high-rise office building.

Figure 4. Reinforced concrete shear walls in the basement parking area of a framed building while under construction.

Figure 5. Wood-framed structure being built upon a reinforced concrete base. This is the same structure as in figure 4, at a more advanced state.

The following comprehensive list (table 7) groups universal building materials employed in each type of construction. Almost all are represented in the catalog (with the exception of infrequently occurring types, e.g., a log load-bearing wall [log cabin]).

Table 7. Comprehensive list of universal building materials in mass and framed construction.

Mass Construction	
Formed, Shaped Material	**Unit Masonry**
Concrete	Stone
Poured in situ or off-site	Rubble (natural, irregular shape)
Without reinforcement	Ashlar (shaped or dressed)
With reinforcement	Brick
With steel rebars	Mud brick (adobe)
With webbing	Kiln-dried brick
	Triple brick
	Quadruple and more brick
	CMUs
	Structural terra cotta
	Brick and block (see U.S. Army Human Engineering Laboratory Technical Memorandum 30-78)
	Poured-in-place concrete with pilasters
	Stone over concrete
	Stucco over brick
	CMU with brick veneer (brick over block)
	Log load-bearing wall
Framed Construction	
Wood Framed	**Steel of R/C Framed**
Post and beam	Light-steel frame
With infill walls	Corrugated sheathing
Wattle	Steel
Balloon and platform	Asbestos
Siding	
Boards	Cladding
Brick	Heavy clad
Stucco	Brick
	Stone
	Concrete
	Terra cotta
	Light clad
	Glass
	Foam concrete
	Aluminum
	Sheet stone
	Fiberglass
	Unspecified
	R/C with infill walls
	CMU
	Brick
	Terra cotta
	R/C mass central pylon
	With steel columns and beams

Note: CMU = concrete masonry unit. R/C = reinforced concrete.

Organizing the catalog's 44 building types by function (but grouped under construction types) yields the following list (table 8):

Table 8. Building types by function grouped under construction types.

Residential (Mass Construction)
Stone house
Triple brick house
Middle Eastern house
Row house
Brick apartment
CMU house
Brick over block
Unreinforced apartment with stone facing
Residential (Framed Construction)
Half-timbered house
Light wood-framed house with wood siding
Light wood-framed house with brick veneer
R/C-framed light-clad apartment building
R/C-framed with brick infill house
Hotels (Mass Construction)
Brick hotel
Box-wall principle apartment building
Hotels (Framed Construction)
Steel-framed heavy-clad hotel
R/C-framed light-clad hotel
Offices (Mass Construction)
Brick office
Offices (Framed Construction)
Steel-framed heavy-clad office building
R/C-framed light-clad office building
Central pylon office building
Retail (Mass Construction)
Mud brick store
Brick store
CMU store
Poured-in-place concrete store
Retail (Framed Construction)
Half-timbered store
Light wood-framed store
R/C-framed brick infill store
Industrial (Mass Construction)
Brick industrial/storage building
CMU industrial/storage building
Tilt-up industrial/storage building
Industrial (Framed Construction)
CMU infill wall industrial/storage building
Terra cotta infill wall industrial/storage building
Very light steel-framed industrial/storage building
Very light steel-framed double industrial/storage building
Institutional (Mass Construction)
Stone church
Brick mosque
Institutional (Framed Construction)
R/C-framed with brick infill wall school

Note: CMU = concrete masonry unit. R/C = reinforced concrete.

7. Catalog Organization

The catalog body consists of a series of four groups of plates for each of the 44 UTBTs. Plate 1 consists of just a single entry (see figure 6). Plate groups 2, 3, and 4 contain from 5 to 12 detailed plates. The number varies with the building type's complexity.

- Plate 1: Place of the building type among major world types.
- Plate group 2: Elevation. Common building elevations for the type, including venting and roof types.
- Plate group 3: Floor Plan. Detailed floor plans for each of the 44 types, including hypothetical projectile paths and the interior walls encountered.
- Plate group 4: Construction Features. Type and dimensions of materials and method of construction.

8. Plate 1: Place on the Building Construction Chart

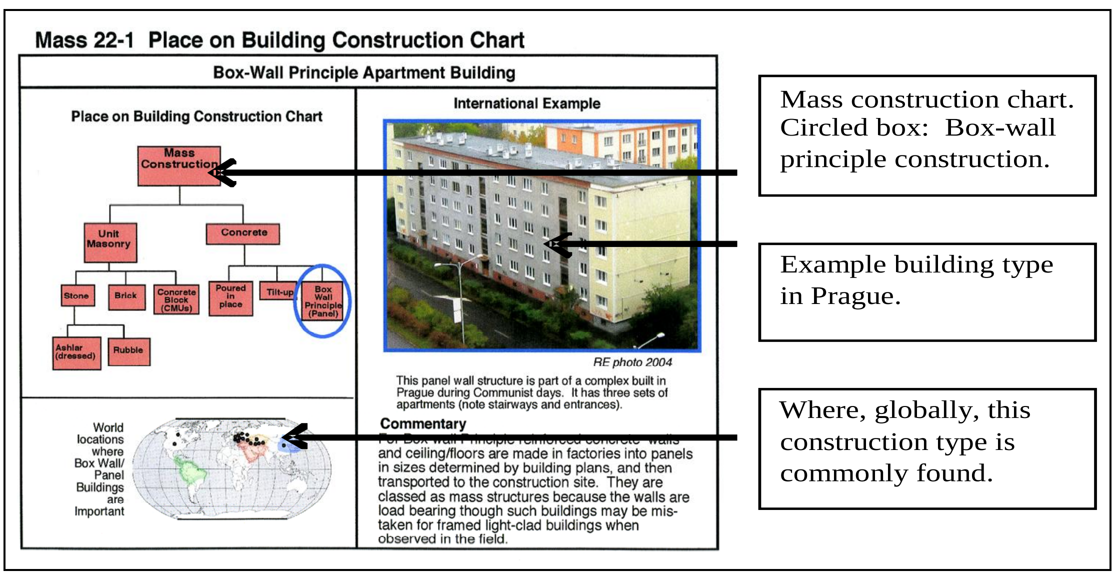

Figure 6. Place on the building construction chart.

This example of a plate 1 (figure 6) begins the series of plates for each UTBT and can be seen in full size as catalog plate 22. Each plate 1 (of 44) consists of the type of construction (circled on the chart), an international photo example, global occurrences of the construction type, and an explanatory commentary.

9. Plate Group 2: Elevation

Profile drawings (elevations) have long been used by architects to demonstrate a planned project for clients. These show window and door placement and, at scale, record venting and other dimensions. All elevations are tied to floor plans. In the catalog, as many elevations as necessary are given for each building type. If front and rear are identical, only one elevation appears. If front, rear, and sides vary, all elevations are shown. Detailed examination and analysis of venting (as depicted in the elevation plates) and roofs (also appearing in the elevation plates) leads to findings as given in the following pages.

9.1 Venting: Windows and Doors

The term venting comprises windows and doors. Venting, in addition to allowing the passage of air through a building, provides lighting, ingress/egress (persons and, in some cases, vehicles), fire safety, and, where appropriate, display of goods or information. Measurements of both windows and doors by building type are included here, shown both separately and in aggregation. See the appendix for 132 measured venting types.

In response to concerns from the urban operations community, the following building characteristics are included in the catalog:

1. Representatives of all UTBTs are measured.
2. Major function types are covered (e.g., residential, commercial, and industrial).
3. Representative buildings from throughout the world are offered.
4. Distinction is made between building elevations, front, back, and side, considering that the number and distribution of windows on commercial buildings in cities are far greater on the front than the rear. Often, when buildings are attached (a UTZ grouping), abutted buildings have no side wall venting at all.
5. Building setting (location with UTZs) is important when considering buildings as artillery targets susceptible to air attacks.
6. Differences between the ground floor and upper floors are also considered. Except for some unusual circumstance, doors can be only at ground-floor level. Accordingly, the proportion of door openings to total exterior wall area in tall buildings is quite small.

9.1.1 Building Construction Type Differences (Mass vs. Framed)

Inherent and essential differences in venting result from the restricting limitations present in mass buildings but not occurring in framed construction. Mass buildings, drawing their support and integrity from the strength and thickness of their load-bearing outer walls—thus having the ability to support the dead load of wall, floor, and roof, plus the live loads of humans and materials—cannot afford to have wall integrity diminished by windows without certain principles being followed. First, windows and doors must be aligned vertically, leaving the undisturbed wall space between to support loads. Second, integrity reduction caused by the window opening must be replaced with some support, such as a lintel above the window (its load being distributed on both sides of the window), or with an arch above the window (both are, in effect, bridges across openings in the wall). Third, the corners of mass buildings cannot have windows, for it is at the corners with their right-angle joining that the mass buildings are the strongest and are able to carry much of the total load. The result is that mass buildings will have a smaller proportion of their walls devoted to windows than will framed buildings.

Framed buildings, where all loads are supported directly by columns or directed to the columns by beams, can have as much wall space devoted to windows as the building designer chooses. In some instances, virtually all exterior walls could be of glass, though requirements of a building's function normally dictate otherwise. Considering that frame members of these buildings bear all loads, while walls (cladding or infill) bear no loads, windows can be placed anywhere on the building's exterior walls, even at the corners. They do not need to be aligned vertically and may be of any size, shape, or variety, as is often called for by the architect to achieve aesthetic effects.

Recognizing these characteristics, this report groups all venting data first by major building construction type (mass vs. framed) and then by generalized function.

9.1.2 Generalizations on Windows and Doors Relative to Building Function

Used in the study are the building functions of houses, apartments, hotels, offices, industrial/storage, and, in the case of mass construction buildings, a class called large masonry structures (churches, mosques, and some institutional buildings).

Window size, shape, and pattern respond to a building's function. Thus:

- Retail stores have large windows to display merchandise.
- Storage buildings have few or no windows.
- Office buildings are designed to provide natural light to workers.
- Industrial buildings have various lighting requirements. Some prefer abundant natural light for factory workers while other industrial functions require little or no natural light.
- Apartments require that each room have some natural light (sometimes by employing a light well) for air circulation, light for activities, and safety.

- Houses have the same requirement. In recent years in advanced countries, window openings are restricted by building code for energy conservation purposes.

The opportunities and constraints imposed by building construction type to match these basic needs are discussed in detail in following sections.

9.1.3 Venting Measurements

Key venting items are window and door dimensions; the proportion of wall space occupied by venting; and forms and patterns of venting seen in various morphological and functional building types. Data were obtained by making measurements from a broad range of buildings (located in urban areas throughout much of the world) in 71 cities located in 41 separate countries. Specifics are in noted in table 9.

Also considered in the selection of measured buildings was the age of structures. Some are several centuries old, some are of recent vintage, and several are under construction (where construction method is revealed).

Buildings of the same function, e.g., hotels, in both mass and frame construction are represented. This shows that the same function may have similar window patterns in either mass or framed construction. In another observation, the lack of constraint on window placement and size in framed buildings results in very large window areas, e.g., modern high-rise glass-curtain wall buildings, structures that are the mode in redeveloped city core areas, and buildings in clusters at major airports and in other outlying commercial developments.

9.1.4 Data Organization

Venting measurements were made using photographs of buildings in cities throughout much of the world. In addition to the 44 buildings shown in the catalog plates, another 49 are incorporated and are referred to collectively as the world set. Data from the 44 plates record venting on all sides of a building. Only front wall venting is measured for the additional 49 plates. Data, organized by building construction type and function, appear in table 10. Combined figures for doors and windows appear in table 11. Separate tables provide data on components of tables 10 and 11, and are listed as:

- Table 11: Percent windows of mass and framed construction buildings in the world set.
- Table 12: Percent windows for specific building types of mass construction buildings in the world set.
- Table 13: Percent windows for specific building types of framed construction in the world set.
- Table 14: Mean window dimensions by groups for mass and framed construction types.

The complete set of window measurements (83 mass construction and 59 framed construction buildings) appears in the appendix.

Table 9. Cities and countries where venting measurements were taken.

Region	Country	Cities
Europe	Andorra	Andorra
	Austria	Linz, Vienna
	Czech Republic	Prague
	Finland	Helsinki
	France	Chartes, Limoges, Paris, Reims
	Germany	Berlin, Braunschweig, Bremen, Falkenberg, Hammelburg, Koblenz, Salzgitter
	Gibraltar	Gibraltar
	Greece	Athens
	Hungary	Budapest
	Italy	Rome, Castellina
	Netherlands	Rotterdam
	Norway	Stavanger
	Portugal	Lisbon
	Spain	Seville
	Sweden	Helsingborg, Norrokoping, Uppsala
	United Kingdom	Bath, Canterbury, Edinburgh, London, Wilton
Subtotal	**16**	**33**
Asia	China	Guilin, Shanghai
	Hong Kong	Hong Kong
	India	Chenai (Madras), Delhi/New Delhi, Mumbai (Bombay)
	Iran	Tehran, Elburz Mountains
	Israel	Haifa, Jerusalem, Tel Aviv
	Japan	Tokyo
	Macao	Macao
	Malaysia	Kuala Lulmpur
	Philippines	Manila
	Singapore	Singapore
	Sri Lanka	Colombo
	Thailand	Bangkok
	Vietnam	Ho Chi Minh City
Subtotal	**13**	**19**
Latin America	Costa Rica	Heredia, Puntarenas, San Jose
	Mexico	Juarez
	Panama	Panama City
	Peru	Lima, Andes Mountain village
	Virgin Islands	St. Croix
Subtotal	**5**	**8**
Africa	Egypt	Cairo, Luxor
	Tunisia	Tunis
Subtotal	**2**	**3**
Australia, NZ	Australia	Sydney
	New Zealand	Auckland, Wellington
	Yap	village
Subtotal	**3**	**4**
North America	Canada	Edmonton
	United States	Baltimore, Philadelphia
Subtotal	**2**	**3**
Total	**41**	**70**

Table 10. Windows as a proportion of front walls (grouped by construction and function type).

Windows as a Proportion of Front Walls UTBT and World Set Aggregated by Groups (Construction and Function Type)						
	Mass Construction			Framed Construction		
Group	No. of Examples	Percent Range	Mean Percent	No. of Examples	Percent Range	Mean Percent
Houses	39	3.9–22.3	11.1	7	7.8–13.1	10.7
Apartments	17	10.4–34.3	17.6	13	9.9–39.4	21.0
Hotels	6	12.4–37.3	16.9	20	12.1–38.0	22.6
Offices	10	9.9–20.5	15.0	19	11.3–58.8	34.3
Industrial/storage	7	5.6–27.4	18.1	9	1.3–7.2	3.9
Large masonry buildings	13	5.1–24.4	8.5	—	—	—
All buildings	92	3.9–37.3	13.4	68	1.3–58.8	21.3

Note: UTBT = urban terrain building type.

Table 11. Windows and doors as a proportion of front walls (grouped by construction and function type).

Windows and Doors as a Proportion of Front Walls UTBT and World Set Aggregated by Groups (Construction and Function Type)						
	Mass Construction			Framed Construction		
Group	Percent Windows	Percent Doors	Percent Windows and Doors	Percent Windows	Percent Doors	Percent Windows and Doors
Houses	11.1	4.7	15.5	10.7	4.5	15.5
Apartments	17.6	5.4	19.9	21.0	4.0	20.6
Hotels	16.9	3.5	23.2	22.6	2.2	23.3
Offices	15.0	3.0	18.6	34.3	2.1	34.3
Industrial/storage	18.1	5.7	14.3	3.9	19.8	16.8
Large masonry buildings	8.5	3.3	10.8	—	—	—
Mean percent	13.4	4.4	16.7	21.3	4.2	25.3

Note: UTBT = urban terrain building type.

9.1.5 Data Analysis

The data in table 10 are grouped by construction type and function.

The functional types listed (houses, apartments, hotels, offices, industrial/storage, and large stone buildings [mass only]) are universal. The data show relationships between function and construction type.

All percentages are mean, not median, and are broadly representative. Data are not just a mean of the percentages. For example, the figure 11.1% for mass construction houses is the mean for all 39 house examples.

The mean percentages that windows form of houses' front walls are almost identical in both mass and framed construction houses (11.1% mass vs. 10.7% framed). Common house architecture and style are more important than the construction method. The universal practice of providing windows to each room is evident. In addition, window size is a near constant for rooms of

various functions (covered in table 14). Bedroom windows are small for privacy and to limit light. By design, kitchen windows are also fairly small. Bathroom windows are even smaller. The largest windows are in the daytime living areas, the living room, the great room, etc. The opportunity to have large windows with framed buildings and their non-load-bearing walls is not taken.

The same principles apply to some degree for apartments, but the percentage differences (17.6% mass vs. 21.0% framed) are accounted for by the fact that framed apartment buildings are often modern-design high-rise structures with large windows enhancing the total appearance of the building. And, especially in upper floors, there is less concern for privacy than in a low-rise building where "view" apartments are desired (and always command the highest rent). The window figure for mass apartments (17.6%) is higher than that for houses (11.1%) thanks mainly to the practice of having glass occupy nearly all of the outer wall of a "box" in box-wall construction.

The figures for hotels (16.9% mass vs. 22.6% framed) show a similar pattern. Not only are large windows seen as desirable, but individual hotel rooms in modern framed construction hotels are larger than those found in older mass buildings. (Small room size has posed a special problem in bringing old hotels up to modern standards.)

Differences between the two forms of construction show markedly when comparing window percentages for offices (15.0% mass vs. 34.3% framed). Part of this difference is that abundant light was always desired in old masonry buildings, but the structure limitations would not allow it. Another reason is the sea change that has occurred in the design and use of offices. Prior to about 1950, office buildings were designed for a market of individual professionals renting single offices. In modern times, with large corporations as major players, offices are designed to have large, open bays with space divided (if at all) with low partitions, i.e., "cubicles."

The reverse is seen with industrial/storage buildings (18.1% mass vs. 3.9% framed). The older buildings (mass) supported functions, such as a textile factory, that needed as much natural light as possible, especially in the early days of electricity. (Largely abandoned factory buildings in New England are good examples.) Modern framed structures, especially large-volume buildings, rely on artificial light, and, in many instances, require a controlled environment.

The entry for large masonry buildings can, by definition, mean only mass construction buildings. Here, the small figure of 8.5% reflects in part the unwillingness to devote much space to integrity-robbing windows and in part to window technology before large plates of glass were viable. The use of small pieces of stained glass in churches is a good example.

The aggregate totals of 13.4% for mass structures vs. 21.3% for framed is telling.

The data in table 11 are grouped by construction and function type. The proportion of wall space devoted to doors is essentially very small, ranging from 2.1% to 5.7% for all structures, excluding framed industrial/storage that has large openings to allow truck entrance. Architects

keep door size to a minimum for security reasons. Doors must be lockable and generally entry-proof. Guards are posted in critical instances.

One reason for differences between morphological/functional building types is simply building height. Low buildings have a higher proportion of doors to walls than do tall buildings. A good example are the figures for houses vs. a tall (framed) office building. The proportion of doors in houses is 4.7% for mass and 4.5% for framed construction, while the framed office class has a door proportion of only 2.1%. Mass construction hotels have 3.5%, but framed hotels, owing to their greater number of floors, typically have only 2.2%. Aggregate figures for all functions are only 4.4% for mass and 4.2% for framed buildings.

The figures for doors and windows combined contributes little to the figures for the proportions of windows (as seen in table 10) due to the relatively low figures for doors.

9.1.6 Discrete Construction Type Buildings by Function

Window-to-wall proportions for specific construction/function forms (table 12 for mass construction and table 13 for framed construction) vary somewhat from the aggregations reported in the previous two tables.

Table 12. Mass construction buildings.

Windows as a Proportion of Front Walls World Set by Specific Mass Construction Building Types			
	Mass Construction		
Specific Buildings	**No. of Examples**	**Percent Range**	**Mean Percent**
Houses			
Stone houses	6	4.6–12.5	7.8
Adobe house	1	—	6.5
Brick houses	12	5.3–22.3	13.9
Brick row houses	6	5.4–16.5	12.1
CMU house	6	3.9–15.3	10.1
Apartments			
Brick apartments	9	10.4–16.9	13.1
Box-wall apartments	6	13.7–34.3	24.2
Hotels			
Brick hotels	5	12.4–22.1	16.9
Offices			
Brick offices	9	9.9–20.5	15.0
Industrial/Storage Buildings			
Brick	5	6.4–27.4	18.1
Large masonry buildings	12	1.6–19.1	8.5
Total Number of Buildings: 77			

Note: CMU = concrete masonry unit.

Table 13. Framed construction buildings.

Windows as a Proportion of Front Walls World Set by Specific Framed Construction Building Types			
	Framed Construction		
Specific Buildings	No. of Examples	Percent Range	Mean Percent
Houses			
Wood framed	4	7.8–11.2	9.1
Apartments			
Light-clad curtain wall	6	13.3–39.4	27.2
Light-clad infill wall	6	9.3–21.3	15.7
Hotels			
Heavy clad	9	12.1–30.9	18.3
Light-clad curtain wall	6	10.7–44.2	21.8
Light-clad infill wall	3	15.9–35.3	28.1
Offices			
Light-clad curtain wall	9	16.3–58.8	41.1
Light-clad infill wall	6	11.3–34.9	22.6
Industrial/Storage Buildings			
Light clad	6	2.1–7.2	4.4
Total Number of Buildings: 55			

For mass-constructed houses (table 12), stone houses (7.8%) and adobe houses (6.5%) have very low window-to-wall percentages. While the form of construction would allow for more and larger windows, other restrictions emerge. Many of these structures are found in poor areas where providing windows represents an unacceptable construction expense. Security is also a factor (a good example are the small windows seen in American frontier log cabins). Another factor is a requirement for as much insulation as possible in desert climates. Finally, in the case of adobe dwellings in Muslim countries, privacy needs are paramount; lighting and ventilation in these cases normally come from a central courtyard and not from windows facing the outer world.

Brick houses, on the other hand, with their higher average window-to-wall percentages (13.9%), are located in the modern Western world and in higher latitudes where lighting needs dominate. Average figures for window percentages here are in the neighborhood of twice those of stone and adobe houses. Figures for row houses (12.1%) and CMU houses (10.1%) show nearly the same differences.

The apartment class has two very different forms of construction, even though they both fall under the rubric of mass. The brick apartments (13.1% window) use unit masonry construction while the box-wall buildings (24.2% window) are made of poured concrete slabs. Brick walls have the usual restriction that wall integrity cannot be compromised while box-wall cells have one open end devoted almost entirely to a window.

The figures for brick hotels, brick offices, brick industrial/storage buildings, and large masonry buildings are repeated from table 11.

The opportunities afforded through the use of frame construction to provide windows larger than those associated with mass construction are clear with only houses having small proportions (just 9.1% for wood-framed houses and industrial/storage buildings with 4.4%, contrasted with double-digit figures for the other building types). Again, style and human scale dominate.

Table 13 makes a distinction between windows that are a part of cladding of a framed structure as opposed to situations where a window forms part of an infill wall. Cladding is applied on the outside of a building's frame while infill walls or windows fill the space between columns and beams.

For apartment buildings, curtain walls have a higher proportion of windows than do those with infill walls (27.2% vs. 15.7% for infill walls). For the hotels measured, however, the infill walls have a somewhat higher proportion of windows (28.1% to 21.8%). These numbers are appreciably higher than the window proportion of heavy-clad hotels (18.3%). For offices, as would also be expected, curtain walls have a higher percentage of glass (41.6%) than do infill walls (22.6%).

9.1.7 Window Dimensions

Several factors affect window size. Building morphology, i.e., mass vs. framed, provides one set of parameters, and building function forms the other.

As noted earlier, buildings of mass construction have the limitation that reduced wall integrity restricts the number and size of windows—framed structures have no such limitation. A curtain wall of a framed building can be all glass, although in practice, opaque glass usually masks floor ends and structural members.

Table 14 reveals significant differences in window size for some building construction types and functions, and very little for others. Little difference is seen for houses whether they are mass or framed (1.2 m^2 for the former, 1.9 m^2 for the latter). Looking at the range of sizes, the size of windows in a house is in direct response to the need and desirability for lighting and ventilation for the various room functions. Daytime occupancy rooms favor larger windows than do sleeping rooms, kitchens, or bathrooms.

The same reasoning applies to apartments, although box-wall apartments will often have large windows at the exposed end of the box, contributing to the aggregate figure for mass apartments (2.4 m^2), while framed apartments are similar at 2.7 m^2.

With hotels, the range is also fairly close (1.9 m^2 for mass to 2.4 m^2 for framed). That the differences are as close as they are reflects the small windows of masonry-styled, heavy-clad framed buildings, even though windows physically could have been designed larger. Also, windows in some modern framed buildings are kept intentionally small where a factor, such as heat preservation in cool climate areas, is a consideration.

Table 14. Mean window size in square meters (grouped by construction and function type).

Mean Window Size in Square Meters by Groups (Construction and Function Type)						
	Mass Construction			**Framed Construction**		
Group	**No. of Examples**	**Range (m)**	**Mean (m^2)**	**No. of Examples**	**Range (m)**	**Mean (m^2)**
Houses	21	0.5 × 0.5 to 1 × 2	1.2	9	1 × 1 to 2 × 2	1.9
Apartments	8	0.75 × 1.5 to 1.5 × 3	2.4	17	1 × 1 to 1.5 × 3	2.7
Hotels	5	1 × 1.5 to 1.5 × 2	1.9	24	1 × 1 to 1.5 × 3.5	2.4
Offices	10	1 x 1.5 to 1.5 × 2	2.1	16	1 × 2 to 1.5 × 40	26.7
Industrial/storage	5	1 × 2.5 to 2 × 2.5	3.8	7	1 × 1 to 1.5 × 5	2.5
Large masonry buildings	11	0.7 × 1 to 2 × 2	2.2	—	—	—
All buildings	60	0.5 × 0.5 to 2 × 2.5	1.9	73	0.5 × 1 to 1.5 × 40	7.8

The greatest difference in window size is seen with mass construction vs. framed construction offices. Windows of the former average but 2.1 m^2, while the aggregate for framed buildings is 26.7 m^2. Many of the glistening high-rise office buildings in major cities throughout the world will have very high proportions of glass, around 50% and more (see photo examples in the appendix).

Window sizes for industrial/storage buildings reverse the previous situation in that the mass construction buildings have larger windows than do modern framed structures because building users were seeking natural illumination for the manufacturing processes conducted within. In addition, buildings were smaller and especially narrower, thus allowing greater natural light to penetrate interiors. Windows on walls of modern industrial/storage buildings would be of little use.

Windows in large masonry structures are traditionally very small (at 2.2%). Some of this is a function of style, e.g., the long, narrow windows of Gothic-style European cathedrals.

9.1.8 Window Thickness

The thickness of window glass, thus the strength, is a function of overall window dimensions. Small-area windows are thin, and big windows must be thicker and stronger. House windows are about 2 mm thick, apartment windows range from 2 to 4 mm, and hotel windows range from 3 to 6 mm. The office windows of high-rise structures range from 6 to 9 mm, where resistance to high winds is a factor. Several forms of protection have been devised.

9.1.9 Window Patterns

The arrangement of a building's windows produces certain replicating patterns. These result in part from the form of construction (mass or framed) and in part from the functions the building serves. For some functions, an architect has several choices. For instance, a modern-framed high-rise office building might have windows placed in long horizontal rows (the spandrel pattern, figure 7), or windows may simply be infills among columns and beams (figure 8). Alternatively, the windows may be bounded by vertical mullions (figure 9) or placed on the outside of the frame members as curtain walls (figure 10).

Figure 7. A framed, light-clad office building with a spandrel window pattern. Glass, both clear and opaque, lies between vertical mullions.

In other functions, such as a framed, heavy-clad, or brick masonry hotel, the structure must provide a window for each guest room, resulting in an easily recognizable pattern. In the case of brick masonry construction, the windows must be aligned vertically so as to maximize wall integrity. Framed, heavy-clad buildings followed masonry style. Relating windows to room function is seen with houses. Observed from outside, window size and placement provide ready clues to the floor plan of a house.

While great variety within window pattern types is found, the following figures will serve to define the general types of patterns.

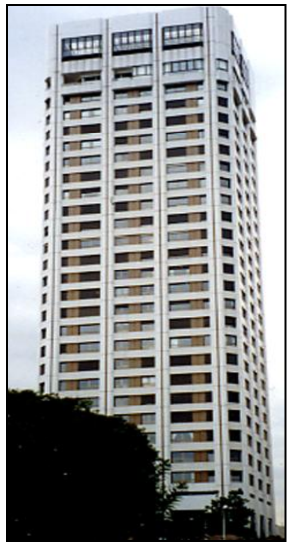

Figure 8. Windows set in between column and beam members in a framed office building form an infill pattern.

Figure 9. An example of a curtain wall being placed on a R/C-framed office building. Glass, clear and opaque, is being placed between narrow spandrels and mullions.

Figure 10. Clear and opaque glass form a curtain wall being installed on a framed office building.

9.2 Roofs

A building's roof—a component of its elevation, its configuration, and its composition—is of key interest to the urban operations community. This report provides geographic distribution of various roofing materials in theaters throughout the world, the morphological and functional types and characteristics of buildings involved, the physical characteristics of the roofing materials themselves, and the shapes of the target roofs. An unanticipated benefit from a focus on roofs is the development of principles involving the nature of building construction, the relationships to climate, the tie to a region's customs, and the presence of various roof types to the level and history of economic development, especially in developing nations.

9.2.1 Method

Examples of the physical shapes of roofs come from a spectrum of cities in various world regions, i.e., Europe, the Middle East, Northeast Asia, Latin America, and Tropical Africa. Cities selected for observation within these regions are listed in table 15.

Visual images came from various sources. For Bremen, a book of aerial oblique photos was most useful, especially when combined with ground truth photographs. For Uppsala, local knowledge plus aerial photo coverage in both oblique and vertical form (supplied by the Swedish government) were used. Cairo was covered by oblique air photographs and supplemented with a Digital Globe satellite image. Ground truth photographs in Tel Aviv were supported with a book of oblique air photos. An enhanced satellite image of Al Fallujah provided the required information. An Ikonos satellite image of Kuwait City gave ample information. An Ikonos

image of Shanghai was also used, supplemented with ground truth photos and oblique photographs posted on the Web. For both Seoul and Pyongyang, a combination of satellite views and oblique and ground photos from the Web were employed. For Panama City, an Ikonos image supported ground truth photos. For San Jose, Costa Rica, a combination of vertical air photographs, low-altitude oblique air photographs taken by Ellefsen, and ground truth photos were used. Finally, for Lagos, an Ikonos image was supported by a Digital Globe image and ground photos from the Web.

A standard procedure was followed in interpreting the information from the images used.

9.2.2 Analysis of Roof Shape

Conclusions can be drawn from examining the data in table 15, which is divided into (1) similarities and differences by class of function, i.e., houses, apartment buildings, offices, commercial buildings, industrial/storage buildings, and institutional buildings, and (2) relationships to regional characteristics, especially the climatic factors of wetness and aridity.

Table 15 focuses on a basic distinction in roof morphology, flat vs. pitched roofs. Considering that all roof forms must have enough slope for water to drain, the term “flat” is used to describe roofs that appear flat to the casual observer. The minimum pitch for a flat roof to have drainage is 20 mm in 1 m. Figure 11 shows a typical flat roof.

Table 15. Roof shapes in selected world cities.

Roof Shape: Selected World Cities Percentage Pitched Roof						
Function/Land Use						
Region/City	**Houses (%)**	**Apartment Buildings (%)**	**Offices (%)**	**Commercial (%)**	**Industrial /Storage (%)**	**Institutional (%)**
Europe						
Bremen	90–100	20–30	30–40	60–70	20–30	90–100
Uppsala	100	80–90	90–100	50–60	80–90	100
Middle East						
Cairo	0	0	0	0	20–30	0
Tel Aviv	80–100	10–20	0	0	70–80	60–70
Al Fallujah	0	0	0	0	30–40	0
Kuwait City	0	0	0	0	80–90	10–20
Northeast Asia						
Shanghai	100	10–20	10–20	10–20	90–100	20–30
Seoul	100	10–20	10–20	0–10	80–90	80–90
Pyongyang	100	20–30	10–20	0–10	80–90	80–90
Latin America						
Panama City	100	10–20	10–20	90–100	90–100	80–90
San Jose	90–100	20–30	10–20	20–30	90–100	90–100
Tropical Africa						
Lagos	100	0	0	0	90–100	90–100

Figure 11. Typical "flat" roof with air conditioning and ventilation units.
Note tar paper strips, parapet, and slight slope to gable roof.

Pitched roofs vary in steepness from around 45° to 20°. In the building trades, roof pitch is a term used to express the ratio of a roof's vertical rise in inches (in the United States) to each foot of run—the horizontal distance. A 3-in-12 pitch describes a roof that rises 3 in vertically for every 12 in of horizontal distance.

Pitched roofs also have a distinctive morphology. See figure 12 for the five basic shapes.

The use of flat or pitched (and degree of pitch) varies in accordance with the following:

1. Climate and the need to protect a structure from heavy and frequent rainfall, or, in some cases, to support heavy snow loads.
2. Availability of local materials for both roof structure and surfacing materials, and access to modern building materials, e.g., steel rebar for constructing reinforced concrete roofs on R/C buildings.
3. Relationship to construction type. For example, R/C roofs are practical for high-rise frame or box wall construction where preparing a roof is simply a repeat of constructing another floor, with the exception that the roof surface must have some protective material.
4. Tradition and style. To be aesthetically pleasing and to match a traditional look associated with a region, pitched roofs are sometimes seen on a framed construction high-rise building.

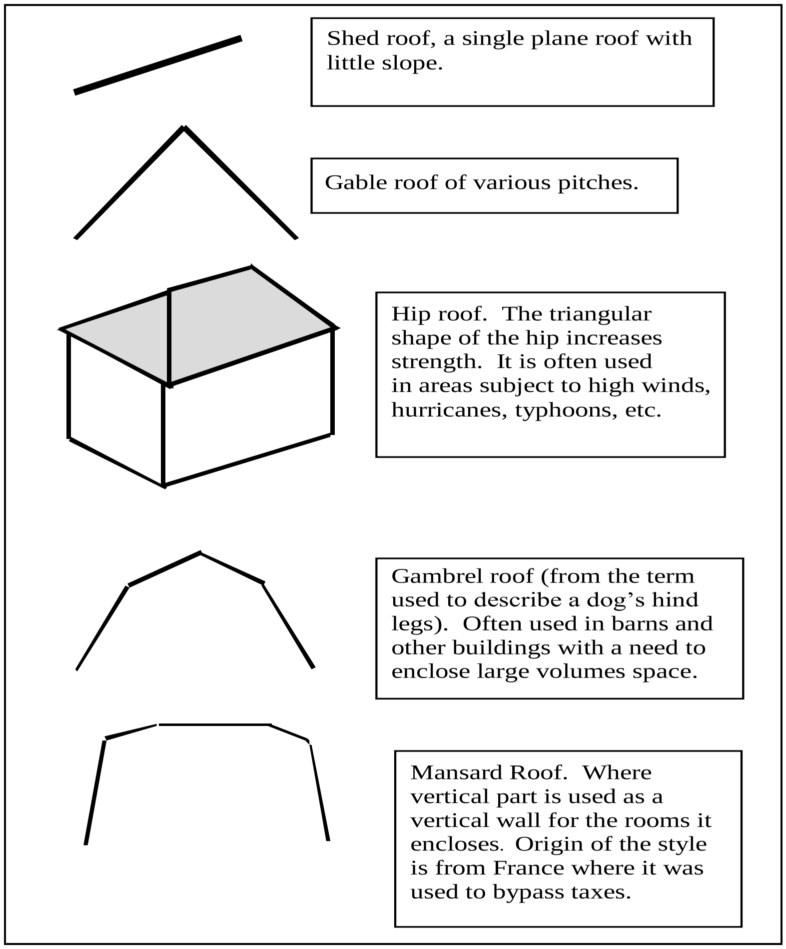

Figure 12. Five basic roof shapes.

9.2.3 Analysis of Building Function

9.2.3.1 Houses. Looking first at houses (refer to table 15), we see manifestations of the previous four principles. Pitched roofs dominate in the two European sample cities, Bremen and Uppsala, with 90% to 100% for the former and 100% for the latter. Response to a damp marine West Coast climate is one response, but historical tradition, tracing its roots to steeply pitched thatch roofs, is also followed (see figure 13).

Houses in the Middle Eastern cities of Cairo, Al Fallujah, and Kuwait City have mainly flat roofs that are not only a response to the dry climates in which they're found, but also to the lack of wood for rafters. In some Middle Eastern cities (such as Baghdad), the flat roofs may have a wall running along the edge of the building (perimeter parapet). The flat roofs of houses in dry climates are well demonstrated by figure 14 of Kano, Nigeria (located in the dry climate area of the northern part of the country). Tel Aviv is the exception, where for free-standing houses (probably because of the European origin of most of the country's citizens) the preferred roof type is pitched. Most are made with semicircular red terra cotta tile.

Figure 13. European row houses with terra cotta tile pitched roofs.

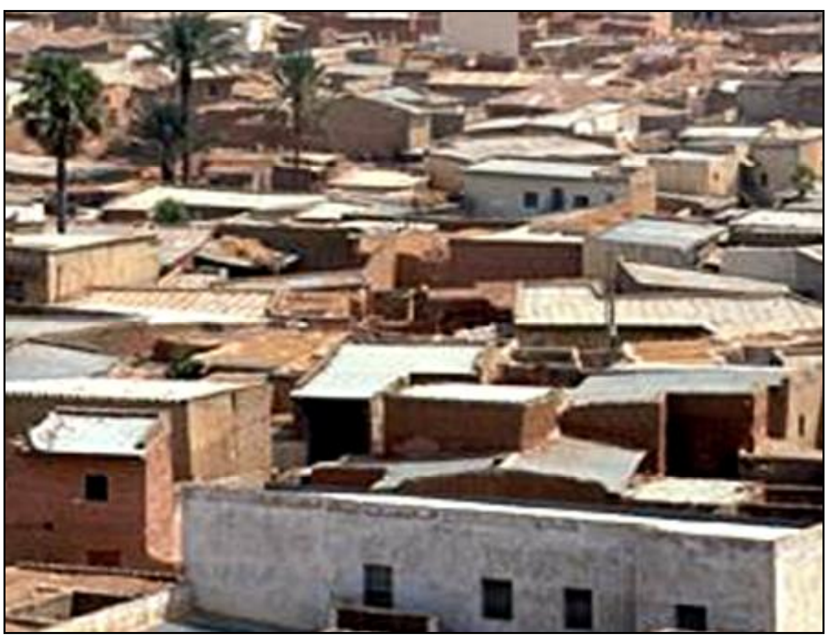

Figure 14. Mostly flat roofs on masonry structures in Africa.

Northern European institutional structures have historically pitched roofs (see figure 15). For the Northeast Asian cities examined—Shanghai, Seoul, and Pyongyang—house roofs are all pitched, accounted for by the generally moist summer climate, the snow in North Korea, and the tradition of pitched roofs in temple buildings where roof shape has spiritual origins. Figure 16 illustrates the point.

Figure 15. Northern European administrative/cultural building with pitched roof.

The Latin American representative cities, Panama City and San Jose, also have predominantly pitched roofs. Panama City, with its tropical rainforest climate (rainfall throughout the year), has a special need for sloping roofs. A few flat roofs are seen in San Jose with its only seasonally wet climate.

Finally, Lagos, also located in a tropical rainforest climate close to the Equator, has a practical need for sloping roofs.

9.2.3.2 Apartment Buildings. The apartment class used here broadly comprises both low-rise buildings (3 to 5 stories) and very tall buildings (50 stories). Both the form of construction (often R/C framed with the taller buildings) and tradition come into play to explain the variances in the proportion of pitched roofs in the different regions. For the European cities, Bremen has a high proportion of flat roofs, especially in the extensive post–World War II developments at the edge of the city. Apartment buildings near the city’s center follow the regional tradition for houses and have pitched terra cotta tile roofs. Uppsala shows this characteristic to an even greater degree with its pitched roof apartments reaching 80% to 90% of all apartment roofs.

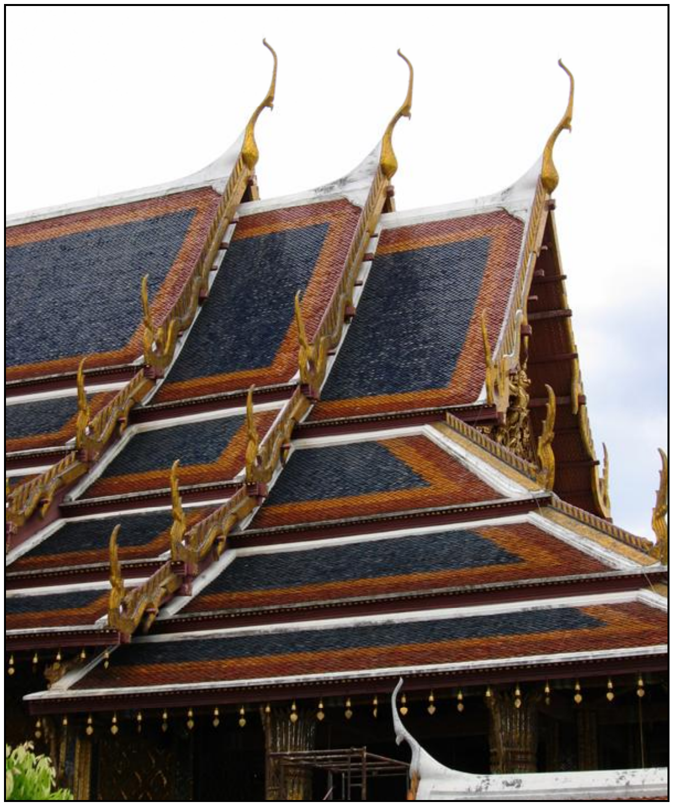

Figure 16. Temple building in Thailand with typical pitched roof.

The same three Middle Eastern cities that have flat-roofed houses also have all flat-roofed apartment buildings. In Tel Aviv, however, thanks to a European-based population tradition, some 10% to 20% of apartment buildings have pitched roofs.

In the Northeast Asian cities, the pitched roof tradition is observed somewhat in Shanghai and Seoul apartment buildings. Their great number of modern R/C-framed high-rise apartment buildings shows the fewest pitched roofs. Tall, flat-roofed apartment buildings also dominate in Seoul and Pyongyang (see figure 17), although a few pitched roof buildings occur.

A small proportion of apartment buildings in the Latin American cities group has pitched roofs (10% to 30%).

In Lagos, even though the tradition of houses is universally pitched, the modern apartment buildings all have flat roofs.

Figure 17. Flat-roofed high-rise apartment buildings in Northeast Asia.

9.2.3.3 Office Buildings. One would expect tall, framed office buildings to have flat roofs. This is essentially true, although some buildings have such roof structures as elevator housings and air-conditioning-equipment protective shelters; some also have reinforced helicopter-landing platforms. Exceptions on the list (table 15) are the European cities Bremen and Uppsala where tradition reigns and climate must be considered. Interestingly, Beijing and other Chinese cities have some office buildings with decorative pitched roofs (see figure 18).

Figure 18. Stylized pitched roofs on Asian office buildings.

9.2.3.4 Commercial Buildings. These structures are mainly lower-rise and are found in central parts of cities and along major commercial streets. Being lower than the high-rise office buildings, many have pitched roofs following the tradition of houses and some apartment buildings. Roughly half of the commercial buildings in Bremen and Uppsala have pitched roofs. A few (0% to 20%) are seen in the Northeast Asian cities. For the Latin American cities, 90% to 100% of Panama City's structures have pitched roofs because of concern with its often heavy rainfall. San Jose, with less of a rain problem, has some 20% to 30% pitched roofs.

9.2.3.5 Industrial/Storage Buildings. Of all the building types in the table, industrial/storage buildings, with only two minor exceptions, predominantly have pitched roofs, regardless of location. The reason is straightforward. Most of these buildings—used either for the manufacturing process, storage, or a combination—require a large volume of interior enclosed space, are not internally subdivided into rooms of various sizes, and do not require air conditioning. Pitched roofs, usually supported by trusses, are common. See figures 19 and 20.

Figure 19. Most of the industrial/storage buildings in this complex have metal pitched roofs.

Figure 20. Metal-roofed industrial storage buildings in South America.

In the Middle East, where a great majority of buildings have flat roofs, high percentages of the industrial/storage structures have pitched roofs. Cairo has 20% to 30%, Tel Aviv has 70% to 80%, Al Fallujah has 30% to 40%, and Kuwait City has 80% to 90%. A common occurrence in an industrial complex is to see a flat-roofed structure housing the administrative offices (almost always air conditioned) while adjacent industrial/storage buildings have pitched roofs. A similar situation is seen in the Latin American cities of Panama City and San Jose, and in the African city of Lagos.

9.2.3.6 Institutional Buildings. Institutional structures, such as governmental, religious, or academic, have traditionally elected to use pitched roofs over flat for architectural and spiritual reasons. Bremen and Uppsala both have classic-styled governmental structures. The Middle East has numerous such structures (see figure 21). In Cairo, Al Fallujah, and Kuwait City, where most other buildings have flat roofs, mosques, museums, and the like have non-flat roofs. Tradition comes into play in Northeast Asia where temples and other monumental buildings have classic, decorative pitched roofs (see figure 16). Panama City, San Jose, and Lagos show the same favoring of traditional pitched roofs.

Figure 21. Terra cotta pitched roofs on academic buildings in the Middle East.

9.2.4 Worldwide Roof Constants

Although aberrations are inevitable when looking at building and roofing practices for cities around the world, certain constants can be identified.

1. Houses in rainy areas have pitched roofs, and those in arid areas have flat roofs.
2. High-rise office buildings, hotels, etc., commonly are light-clad framed structures or box-wall principle structures and, accordingly, have flat roofs, unless some cultural factor governs architecture.
3. Commercial buildings (stores for goods and services), especially along major streets or roads, have flat roofs.
4. Industrial/storage buildings will mainly have pitched roofs.
5. Institutional buildings will also mainly have pitched roofs.
6. Modern high-rise, framed construction buildings have been erected in great numbers in the developing world in recent decades, and most have flat roofs made with concrete.
7. Corrugated (and shaped) metal (steel, aluminum) is in wide use throughout the world for industrial/storage buildings. These buildings normally have pitched roofs. They are

especially common in wet tropical areas. The material is also frequently used in shanty towns (see figure 22).

8. Corrugated and shaped composite roof sheets are also widely used.

9.2.5 Roof Material Types

9.2.5.1 Concrete. Concrete is commonly used for flat roofs and especially for R/C-framed or box-wall buildings where the roof is simply another floor with weather proofing added. Foamed light-weight concrete can take the form of shakes or planks and can be used for pitched roofs when the underlying roof structure is made sufficiently strong. With flat roofs, factory-made lightweight foamed concrete planks are often used and placed upon a supporting structure. Or, a layer of concrete may be poured on top of a corrugated steel base, reinforced with a steel mesh layer. A layer of felt is usually laid on top of the concrete with a layer of bitumen (asphalt and coal tar pitch) atop that. A thin layer of gravel (10 to 13 mm) is placed atop the bitumen to protect the felt and the bitumen. Figure 23 is an example.

Figure 22. Corrugated steel roofs on shanties in Asia.

9.2.5.2 Terra Cotta. Tiles of this material have been used since early times, taking a flat form, a concave, or a convex form and laid on a pitched roof in an overlay pattern (with the covered part thinner than the uncovered part); thickness varies from 10 to 20 mm. A mix of flat and convex tiles is seen in the photo of rooftops in southern Europe (figure 24). Ribbed tiles are seen on the hip-roofed house in South Asia (figure 25).

9.2.5.3 Wood. Sawn shingles and split shakes are commonly used where wood is plentiful or can be imported at low cost.

Figure 23. Concrete flat roofs on buildings in the Middle East.

Figure 24. Terra cotta–tiled roof in southern Europe. Detailed photo shows a common practice of convex tile placed over flat tiles.

9.2.5.4 Metal. Steel and aluminum are used widely for roofing and fabricated into a great variety of shapes, from simple corrugation to many forms of ribbing. Thickness is only 1 to 3 mm. A typical developing nation shanty in Asia shows ribbed galvanized sheet-metal steel in various stages of rust (figure 22). Figure 26 shows a ribbed steel-pitched roof on the middle house (terra cotta tile on the left house and rolled asphalt material on the flat roof on the right). Corrugated steel is classed by the distance between the ridges; a common figure is a ridge to ridge distance of 2 1/2 in with a 1/2-in-deep valley. Thickness is reported by gage.

Figure 25. Ribbed terra cotta tile hip-roof on a CMU construction in South Asia.

Figure 26. Ribbed steel roof (middle), tile roof (left), and rolled roofing (right) in northern Europe.

9.2.5.5 Composite. Various fibers are combined with resins to form an effective roof material; coir (from coconuts) and jute are used in India. Asbestos has been employed widely. Thickness is usually greater than with metal, ranging from 4 to 8 mm. Sheets are often made of a combination of asbestos fiber and Portland cement. The product is light gray in color and, as it doesn't require paint, it is readily identified in the field. Lightweight steel-framed industrial/storage buildings will frequently use this material.

9.2.5.6 Brick and Stone. Brick and stone are used in dome and vault forms to enclose space. They are also widely used in mosques and houses in arid Middle Eastern areas. Low brick arches are used in conjunction with joists to form flat roofs; a veneer of concrete is put on top.

9.2.5.7 Wattle. Integrated with mud, this material is seen on many adobe houses in the Middle East.

9.2.5.8 Thatch. A traditional roof material in Europe and elsewhere in rural areas, but not often seen today.

9.2.5.9 Pitched Roof Support. Pitched roofs are supported by rafters on which purlins are attached at right angles. Trusses may be required to support these.

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10. Plate Group 3: Floor Plans/Room Dimensions

Floor plans are provided for each of the 44 building types. Planimetric plans are provided for each building type, and, in some instances, isometric drawings (at 45°) are included to enhance the visual perception of building interiors. For multiple floor buildings, the upper floor (in the case of a two-story building) is provided, and for buildings with more than two floors, a representative upper floor plan is given. Note that the terms ground floor and upper floors are employed to be compatible with international standards. The U.S. usage of the term "first floor" for the "ground floor" is not applied abroad where the term ground floor indicates exactly what that suggests, with the first floor above the ground floor being designated the first floor, and so on to the full height of the building.

Room dimensions are given in meters. Venting (windows and doors) is shown at scale, as are dimensions of both exterior and interior walls. An example of a single-story industrial/storage building is displayed in figure 27 (from plate framed 16-3-a in the catalog).

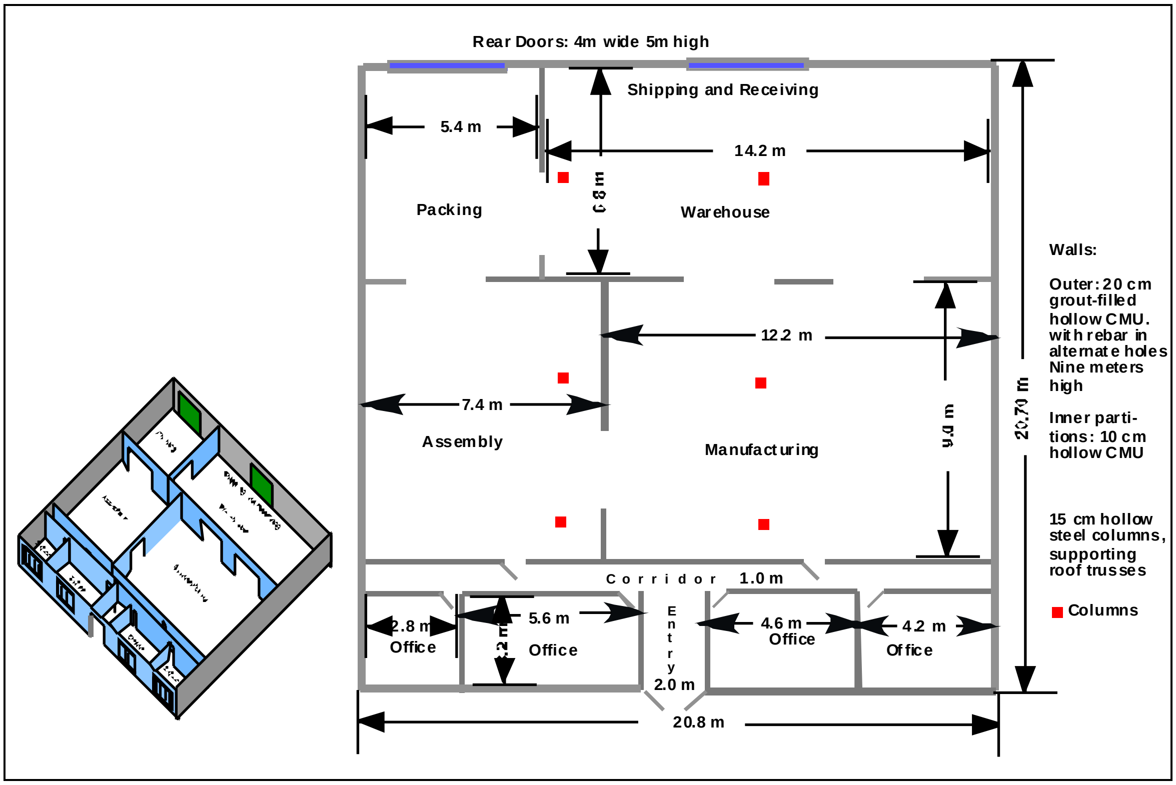


Figure 27. Planimetric floor plan and isometric rendering of an industrial/storage building.

Table 16 gives room dimensions by functional classes of the 44 building types (houses, apartments, row houses, hotels, offices, industrial/storage buildings, retail stores, and institutions). Specifics are given by type of room within these functions where applicable, e.g., living rooms, bedrooms, kitchens for houses and apartments/row houses.

Typical floor plan dimensions of length and width, extracted from the planimetric floor plans for each building type, were used to calculate the average room area (in square meters). The average room volume (in cubic meters) was calculated by multiplying the average room area by the room height.

The number of rooms is given by type, as are range, area, height, volume, and type of UTZ where found. The ranges in room sizes are narrow in residential cases but spreads are greater for rooms located in hotel public areas, corporate offices, industrial/storage spaces, retail stores, and institutions.

The room sizes recorded in table 16, although derived independently, are consistent with the room measurements provided in other independent works such as Harold R. Sleeper's *Building Planning Design Standards*.

Table 16. Room dimensions by function for worldwide buildings.

Function	Number of Cases	Range (m)	Average Area (m^2)	Height (m)	Average Volume (m^3)	UTZs Where Found
Room Dimensions: By Function for Worldwide Buildings						
House						
Living room	12	4 × 4/8 × 4	21.5	3	64.5	A3, Dc3, Do3
Bedroom	27	3 × 3/4 × 5	13.1	2.5	32.9	A3, Dc3, Do3
Kitchen	12	2 × 3/4 × 4	10.8	2.5	27.1	A3, Dc3, Do3
Apartments/Row Houses						
Living room	8	4 × 3/6 × 4	20.1	3	60.4	A2, Dc2, Do2
Bedroom	10	3 × 3/5 × 3	12.9	2.5	32.3	A2, Dc2, Do2
Kitchen	11	2 × 2/4 × 2	7.5	2.5	18.6	A2, Dc2, Do2
Hotels						
Guest rooms	6	6 × 4/4 × 3	17.8	3	53.5	A1, A2, Dc1
Public rooms	5	16 × 10/40 × 21	417.2	5–7	2639.2	A1, A2, Dc1
Offices						
Private	11	7 × 4/8 × 6	37.9	3	113.7	A1, A2, Dc1, Dc5
Pub/Corp.	8	8 × 8/30 × 20	242.3	4–6	1288.5	A1, A2, Dc1, Dc5
Industrial/Storage						
Functional spaces	10	7 × 5/40 × 25	428.0	6–8	3032.4	A4, Dc4, Do4
Retail Stores	3	10 × 6/36/30	406.7	3–6	2326.7	A1, A2, A5, Dc1
Institutional	4	7 × 12/16 × 12	125.0	4	500.0	Dc6, Do6

Note: UTZ = urban terrain zone.

As would be expected, rooms in houses (living rooms, bedrooms, and kitchens) are all slightly larger than those found in apartments and row houses.

In the main, house rooms in most parts of the world will be smaller than the U.S. average. Still, they cannot be smaller than the minimum required for particular functions, considering that the size of humans and furniture is virtually universal.

While dimensions for houses and apartments/row houses show relatively little variance, hotel guest rooms show even less, considering the dedicated use of the rooms and the requirement for hotel builders to attain maximum cost-benefit. Public rooms do, of course, vary with need and function of the hotel (a hotel providing only guest rooms vs. a large convention/business-type establishment). At any rate, volumes of public rooms in major hotels are large and on par with many industrial/storage buildings or retail stores.

For large public space use or corporate offices—associated with framed high-rises—room size and volume are often large. A not uncommon situation is to find a room the width of a prestressed concrete beam (some 10 m) and the length of a few of these beams, giving a total open area often exceeding 300 or 400 m^2 and broken only by cubicle partitions.

The figures for the industrial/storage buildings reflect only the sample structures in this volume and do not include truly large industrial structures, such as an automobile or aircraft assembly plant.

Retail stores also range from the small examples herein (seen in crowded parts of developing nation cities) to the largest "big box" stores.

The last entry, institutional, cannot include the largest (but relatively rare) enclosed spaces, as in a major church or sports arena, but is intended to be representative of those widely encountered average spaces, such as schools.

11. Plate Group 4: Construction Features

Construction features illustrated in this group of plates vary in accordance with the nature of the particular type of construction. For mass construction (table 17), emphasis is placed on the types and dimensions of the material—concrete, the masonry units of mud brick, kiln-dried brick, CMUs, and terra cotta. Brick bonding types are also shown. Details are provided on concrete panel walls as used in box-wall principle construction and tilt-ups.

Mass construction examples include (1) mud brick composition, dimensions, and how they're made; (2) materials and methods used in roofs of simple adobe buildings; (3) method of laying triple brick walls using English bonding; (4) nature of ultra-thick brick walls as seen in multistory brick buildings; and (5) composition and dimensions of R/C box-wall principle buildings.

For framed construction (table 18), the emphasis is on the nature of the frame and either the wall cladding or infill. Framed construction examples include (1) details on joining components of post- and beam-wood construction; (2) the form and composition of heavy cladding on tall steel-framed buildings; (3) the nature of central pylon construction used for some high-rises; (4) variations in infill materials as used in R/C-framed buildings; and (5) nature of very light corrugated steel walls in industrial/storage buildings.

12. The Catalog of Urban Terrain Building Types

The catalog is designed to serve as a reference to users interested in buildings as target types and support to urban operations worldwide by providing information on typical structures and construction types found in each region. Tables 4 and 5 provide the summary view of basic forms of construction. Table 6 provides building properties, e.g., wall and material thicknesses,

for the 44 urban terrain building types in one location for easy reference. The catalog offers specific data on all of the 44 universal building types. This is achieved in the 122 plates covering 23 mass construction building types, and the 121 plates covering the 21 framed construction building types.

Table 17. Mass urban terrain building types.

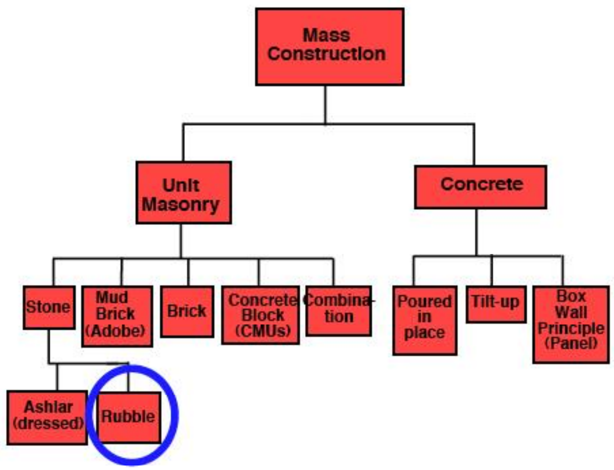
Twenty-Three Urban Terrain Building Types			
Building Type	**No. of Plates**	**Building Type Name**	**Building Material**
Mass 1	5	Stone house	Stone
Mass 2	6	Stone institutional building	Stone
Mass 3	7	Adobe house	Sun-dried mud brick (adobe)
Mass 4	8	Adobe store	Sun-dried mud brick (adobe)
Mass 5	8	Triple brick house	Kiln-fired brick
Mass 6	8	Triple brick Middle Eastern house	Kiln-fired brick
Mass 7	8	Brick row house	Kiln-fired brick
Mass 8	6	Brick apartment building	Kiln-fired brick
Mass 9	5	Brick hotel	Kiln-fired brick
Mass 10	5	Brick office building	Kiln-fired brick
Mass 11	5	Brick store	Kiln-fired brick
Mass 12	5	Brick mosque	Kiln-fired brick
Mass 13	5	Brick industrial/storage building	Kiln-fired brick
Mass 14	6	CMU house	CMUs
Mass 15	5	CMU store	CMUs
Mass 16	6	CMU industrial/storage building	CMUs
Mass 17	5	Brick-over-block house	CMUs and brick
Mass 18	7	Brick-over-block house German house	Large CMUs and brick
Mass 19	6	Concrete with stone cover apartment building	Poured concrete and stone
Mass 20	5	Concrete stone	Poured concrete
Mass 21	6	Tilt-up industrial storage building	Poured concrete
Mass 22	11	Box wall principle apartment building	Concrete panels
Mass 23	5	Box wall principle hotel	Concrete panels
Total Plates: 143			

Note: CMU = concrete masonry unit.

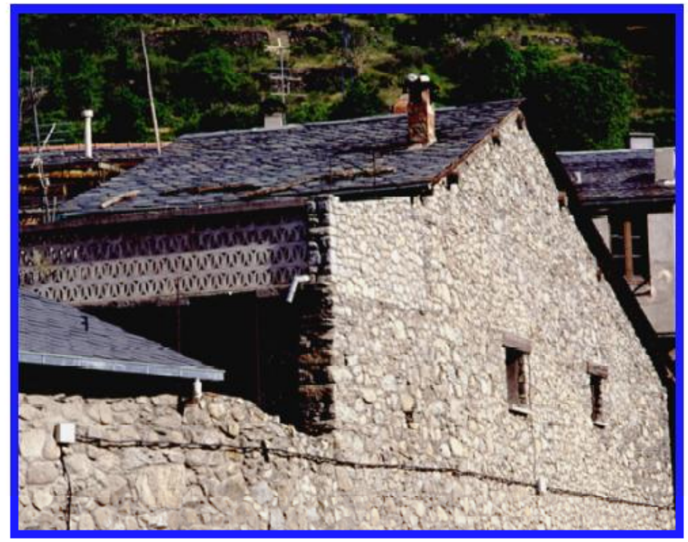
Mass 1-1 Place on Building Construction Chart

Stone Construction: House

Place on Building Construction Chart

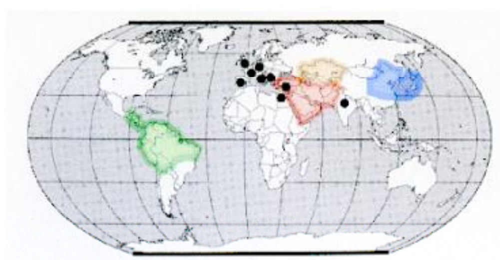


International Example



RE photo

World locations where Stone buildings are important



This example stone house, in Andorra, is made with rubble stone. Unlike construction with ashlar stone, masons must use substantial amounts of mortar to fill interstices between and among the individual irregularly shaped stones. Ashlar cut stones, or bricks, or wooden lintels in this case, must be used to provide squared window and door openings. Note variations in wall thickness, thicker in exposed lower floor, thinner for upper floor, where load is less.

Figure 28. Mass 1-1 place on building construction chart.

Mass 1-2 Elevation

Stone Construction House

Commentary

This example, in a fortified hilltop village in Italy, shows a house with ashlar stone exposed on the two lower floors and rubble stone exposed on the top floor. Several modifications are suggested (by the presence of two entry doors) in this building that is at least 500 years old. Note: alignment of windows to preserve wall strength; and the tile pitched roof.

Terra cotta tile is used as a roofing material. The tiles lie on slats, at right angles, and the slats rest on rafters.

RE Photo 2004

Figure 29. Mass 1 elevation.

Mass 1-3-a Floor Plans

Stone Construction House

Floor Plan: Ground Floor and Upper Floor

Commentary

Stone houses were built in pre-industrial times in many parts of the world, and especially where ample stone resources were available and substitutes, such as wood, were not, and before the advent of cheap, manufactured brick. House plans were usually simple, as in the example. Most rooms served several functions, and did not include indoor plumbing. Window and door openings were necessarily narrow as wider ones would require heavier use of some means for replacing lost strength in a load-bearing wall. Commonly used were arches or lintels. Another reason for keeping doors and windows small is the need for squaring walls around openings through the use of ashlar stone or brick.

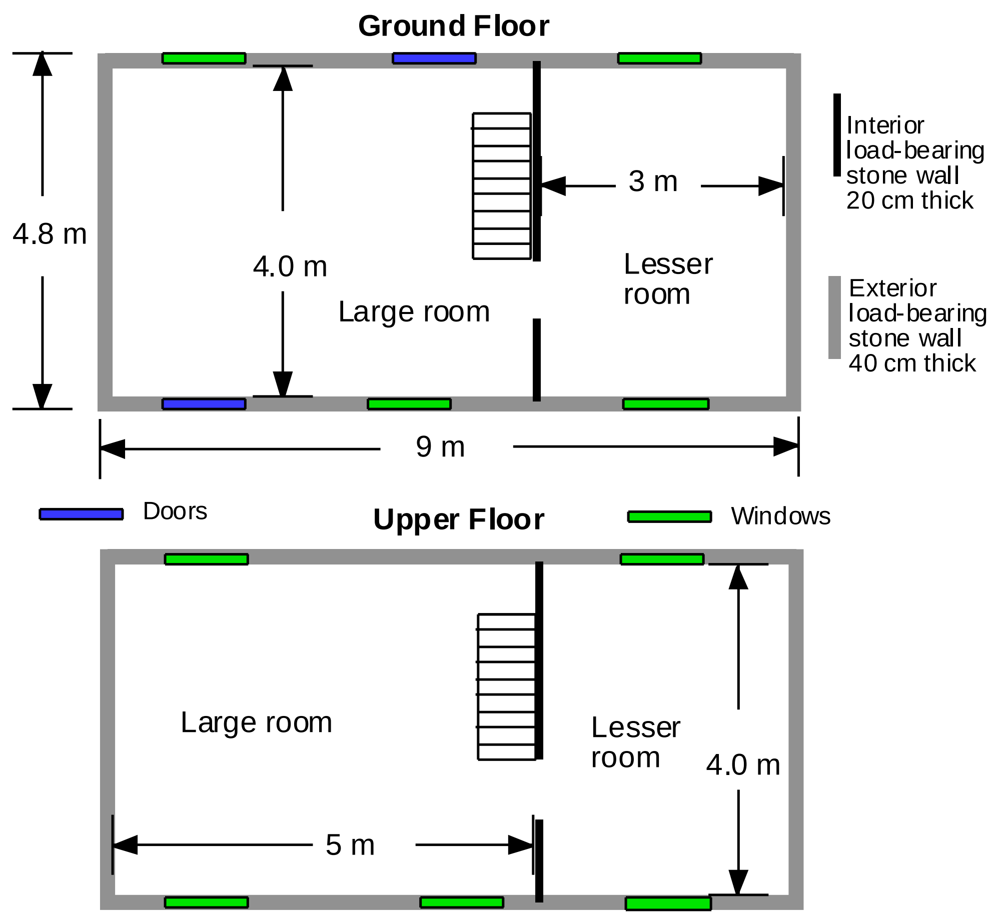


Figure 30. Mass 1-3-a floor plans.

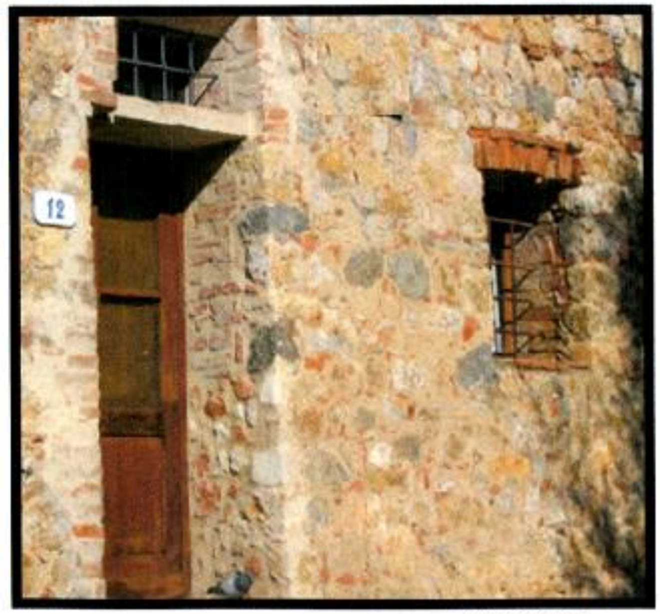
Mass 1-4 Construction

Stone Construction House

700-Year-Old Buildings, Italy

Stone House Construction Examples

RE Photo



RE Photo

Commentary: Immediately striking in these views of old stone houses is the mix of exposed building materials. A few ashlar stones are visible, used particularly for squaring building corners, in arches, and around doors and windows. Also visible are indications of wall repair over the centuries involving rubble stone, brick, and parts of ashlar stone. Wall thickness of around 40 cm is visible in the doorway and window in the right frame.

Figure 31. Mass 1-4 construction.

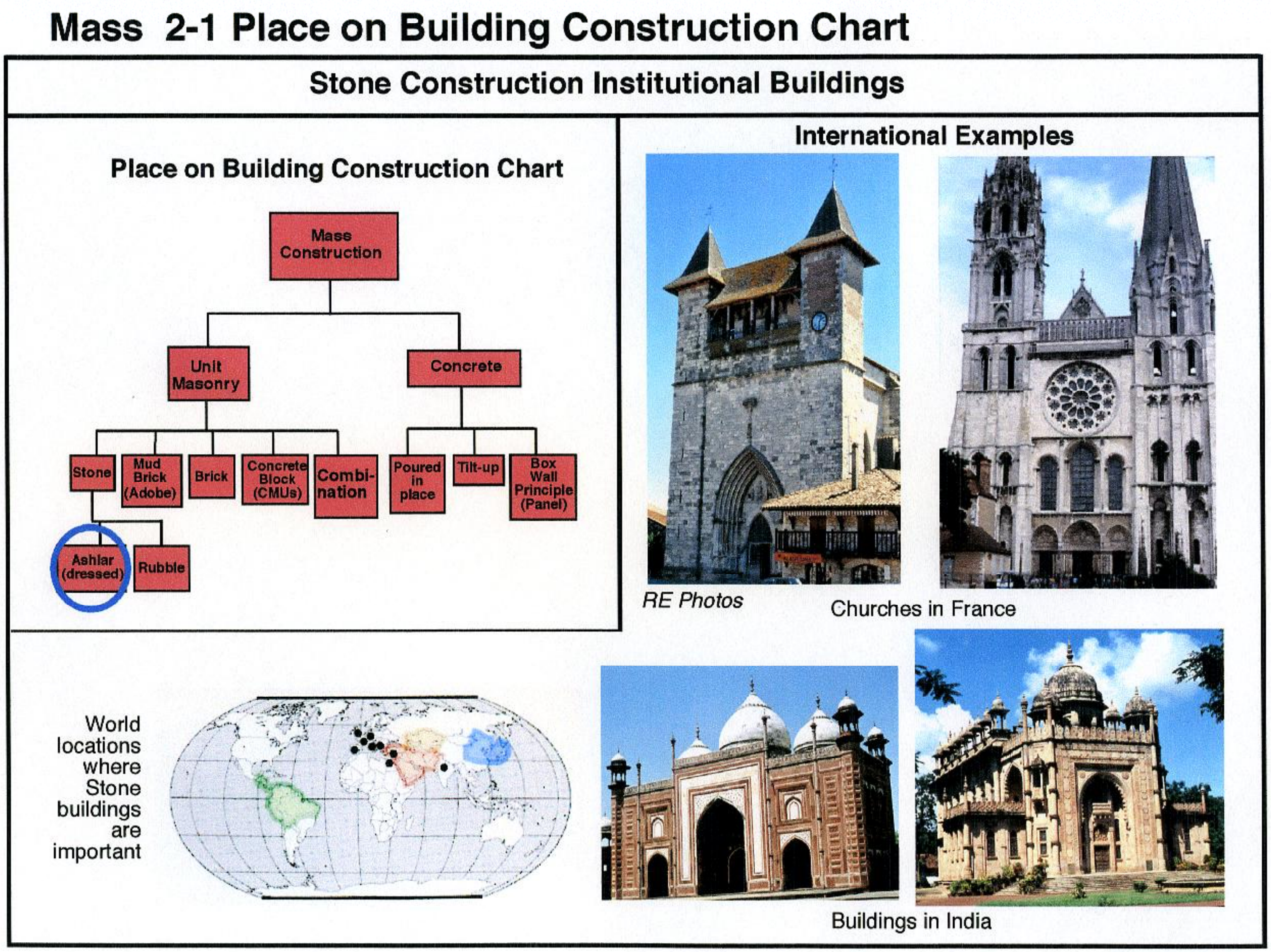


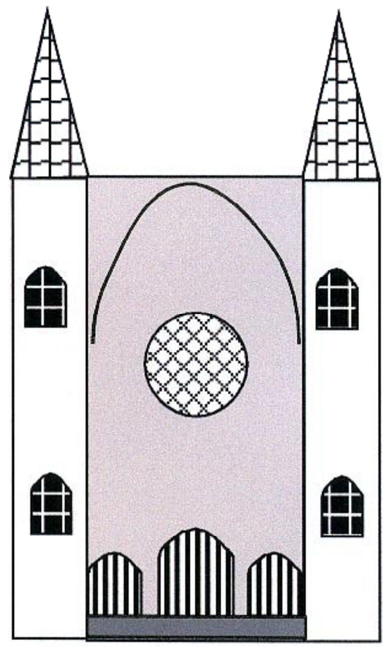
Figure 32. Mass 2-1 place on building construction chart.

Mass 2-2 Elevations

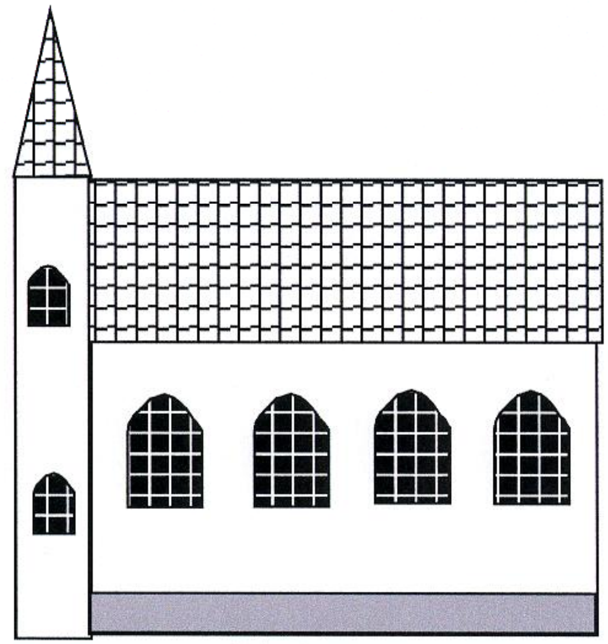
Stone Institutional Building

RE Photo

A church in France.



Front Elevation



Side Elevation

Commentary

Shown here is a stylized example of a classic European church. Many stone structures were constructed over a period of several hundred years, ranging in architectural style from Roman through Gothic. The photo example is of a church in France. Windows employed small panes, often of stained glass. Dimensions are not included considering the great variation in extant examples.

Figure 33. Mass 2-2 elevations.

Mass 2-3 Floor Plan

Stone Institutional Building

Commentary

Shown here is but a single example of an institutional stone building. Being constructed over a long period and in many places throughout the world, variety of architecture and floor plans varies widely.

Common architectural details are, e.g., stone columns, thick (1 plus meter) outer stone walls, great height, and floor plan in the shape of the Christian cross, typical of churches in Europe, and emulated elsewhere.

Figure 34. Mass 2-3 floor plan.

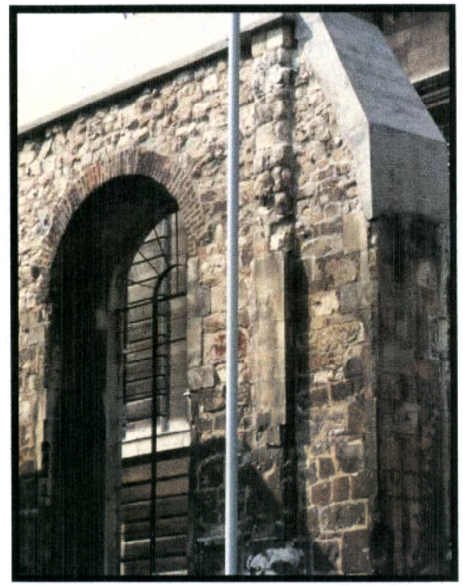
Mass 2-4-a Construction

Stone Construction Institutional Buildings

RE Photo

This building (in Tunis, Tunisia) provides a good example of the use of ashlar (dressed) stone in conjunction with rubble (irregular) stone units, the ashlar (being much more expensive and requiring intensive labor with simple tools) used to square corners while the irregularities of the rubble stone are compensated through use of ample quantities of grout.

Rubble stone theoretically offers less resistance to a munition than would the fitted ashlar stone.



RE Photo

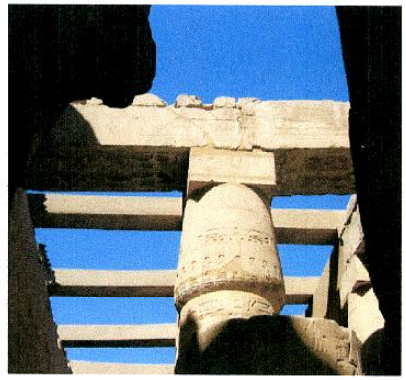
This wall (in a building in London) uses three different materials to offset the irregularities of rubble stone: ashlar units at the wall end, concrete near and at the top, and brick to form an arch at the window. Note the remnants of a pilaster, part in rubble stone and part in ashlar stone.

Figure 35. Mass 2-4-a construction.

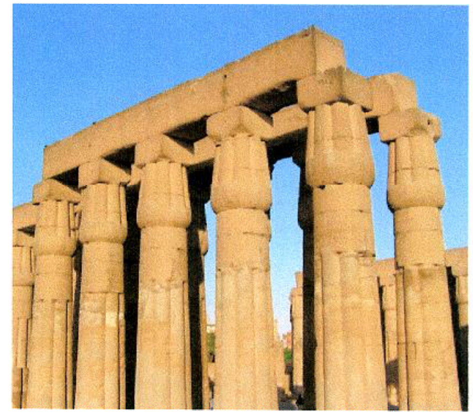
Mass 2-4-b Construction

Use of Stone in Ancient Egypt (in Luxor)

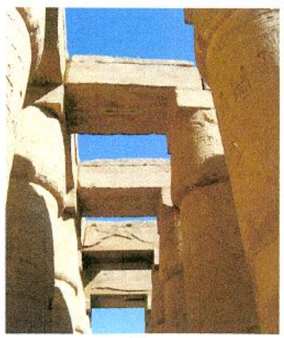
A



B



C



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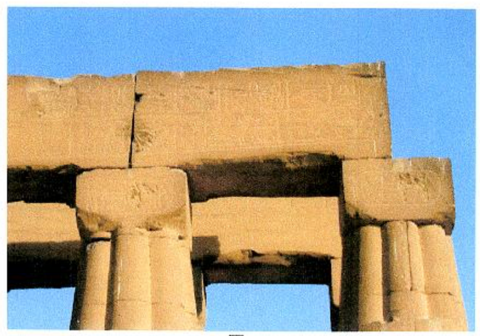
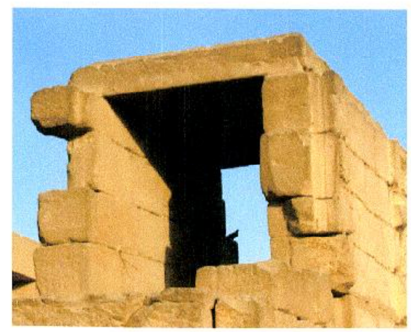


E



F

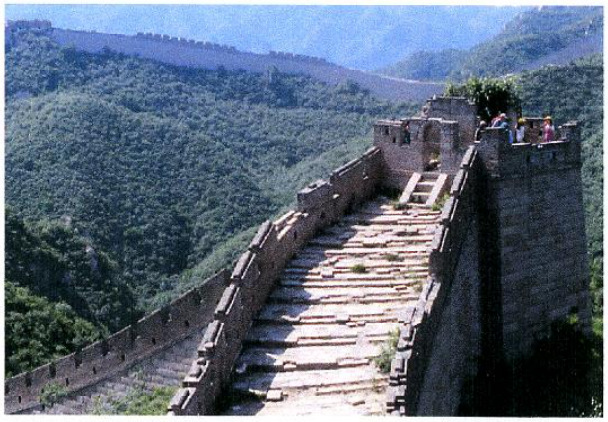
RE Photos

Commentary Basic principles of stone construction are illustrated here. Stone has great compressive strength but little tensile strength. Thus, beams (lintels) could not be very long without encountering their bending moments and breaking. Short beams demanded closely spaced columns that, in order to achieve great height, had to have wide girth at their bases. A: large, closely spaced columns. B: Extant beams once had wooden joists to support a roof. C: Long beams are composed of shorter beams, as seen in D and E. F. A true mass construction stone room, albeit small.

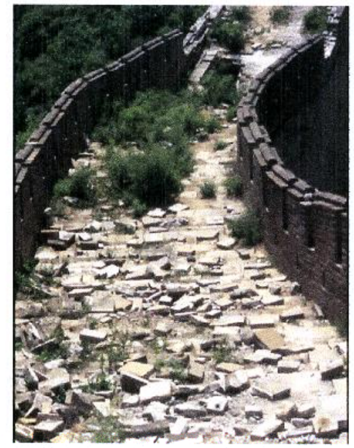
Figure 36. Mass 2-4-b construction.

Mass 2-4-c Construction

Principles Concerning Stone Walls



China's Great Wall manifests the principle that a wall exterior will employ ashlar (dressed) stone while rubble stone is used in the interior. The roadway on the wall top, on the right, has disintegrated to the point where vegetation is growing in the exposed soil. Note the use of brick for the castellated walls. *RE photo*



The rubble stone wall, on the left, was covered with thin sheets of stone to give the appearance of ashlar stone. Wall is in Greece. *RE photo.*

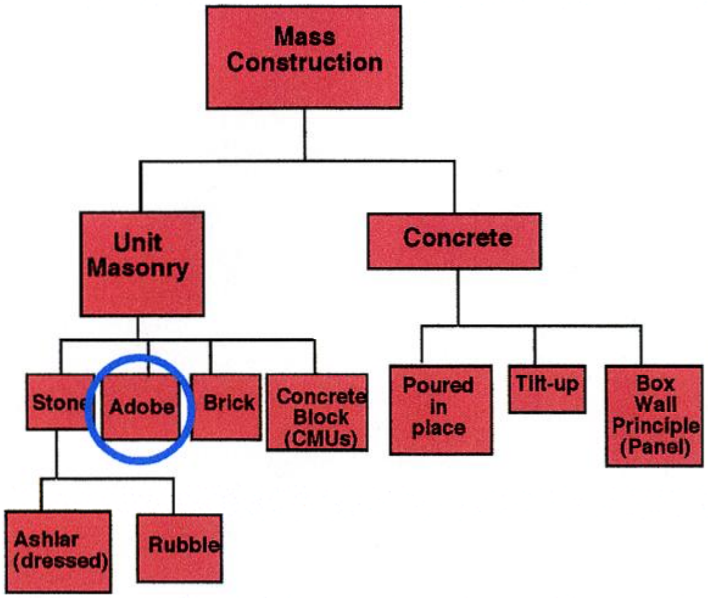
Stone walls, as is also true of brick walls, are thicker at the base to support loads than they are above. *RE photo*

Figure 37. Mass 2-4-c construction.

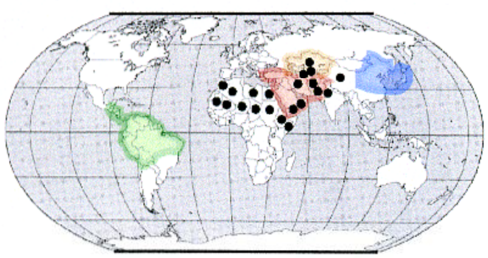
Mass 3-1 Place on Building Construction Chart

Adobe House

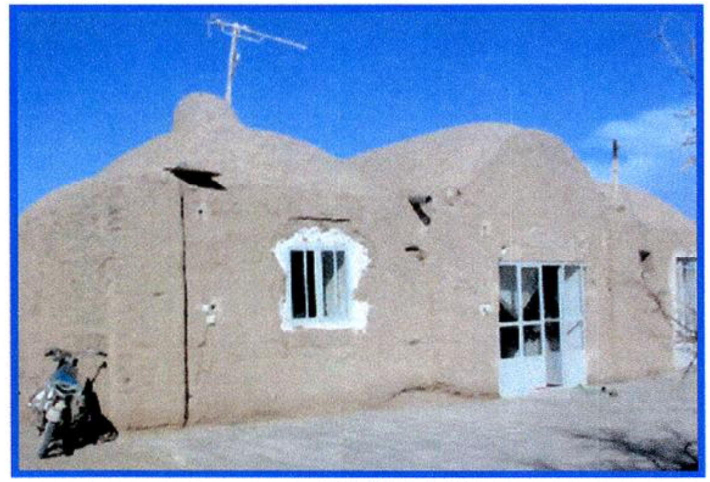
Place on Building Construction Chart



World locations where Mud Brick buildings are important



International Example



Buildings constructed of adobe bricks (sun-dried mud with a straw admixture) are found in hot, dry areas having no access to timber, or in economies without the means to produce kiln-dried bricks, concrete, or steel.

This exterior view — of the same Iranian adobe house depicted in the accompanying graphics of structure, adobe bricks, and floor plan — shows the two types of roofs of such structures. Each of the 4 x 4 meter rooms has its own dome (also made of adobe brick) while the center section employs a vault. Domes or vaults are necessary where wood for roof joists is not available.

Figure 38. Mass 3-1 place on building construction chart.

Mass 3-2-a Elevation and Isometric Rendering

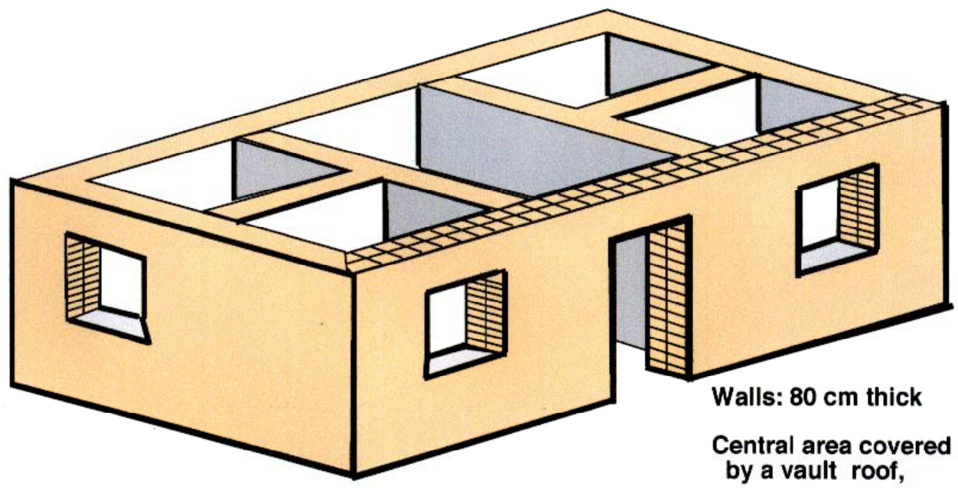
Adobe House

Commentary

Using a standard size for adobe bricks in Iran — 40 x 26 x 10 cm, and using a conventional triple brick method of building walls — results in 80 cm thick walls. Such thickness is required for strength and insulation from seasonal temperature extremes.

The Iranian example here has domes and a vault roof (for the center section). Adobe houses, where wood is available, will have flat roofs composed of, from bottom to top: (1) wooden floor joists, usually poles, often projecting out through the upper wall; (2) boards laid cross-wise to the joists; (3) reeds covering the boards (a sort of lath); and (4) a mixture of adobe mud laid on top of the reeds.

Typical Iranian Adobe House

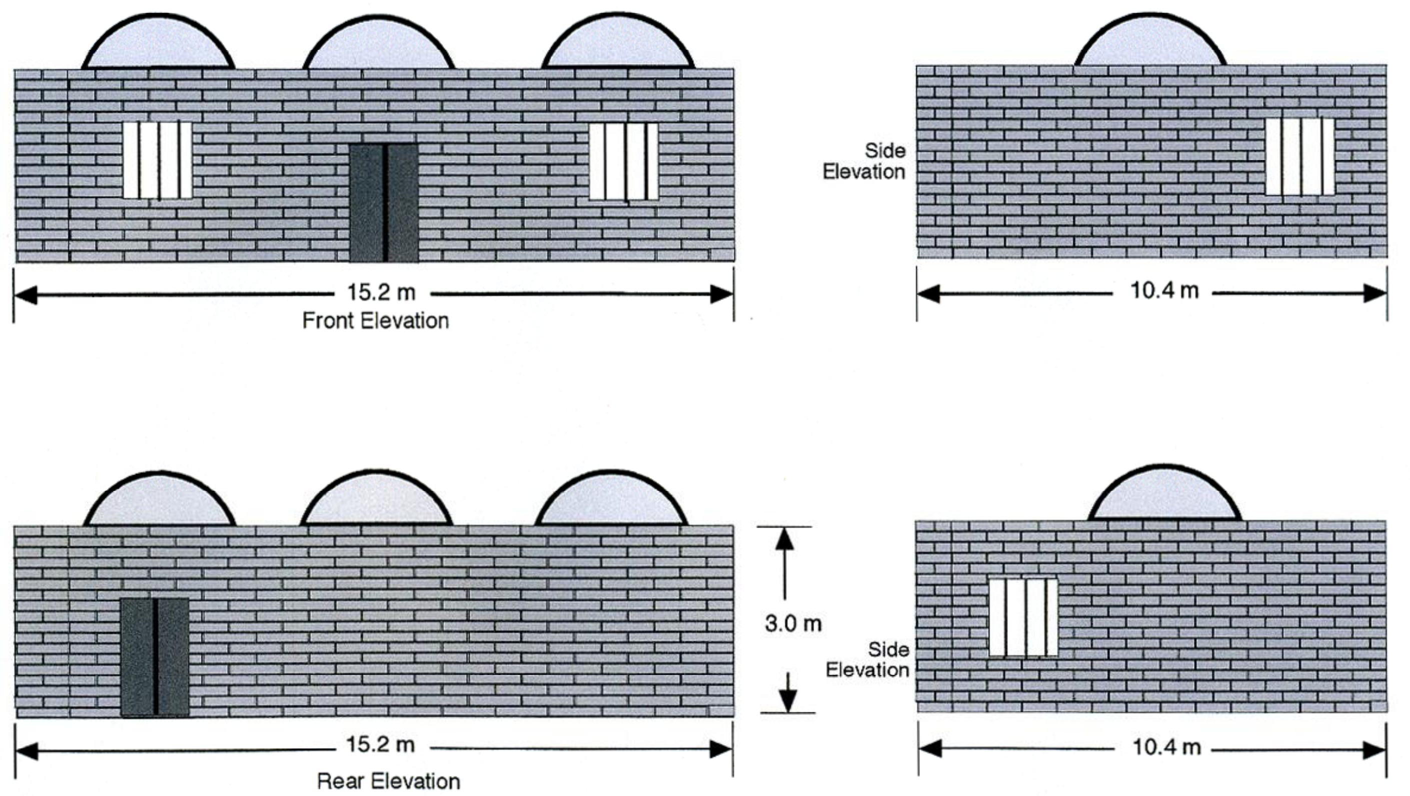


Source: ***World Housing Encyclopedia Report*** **(Rept. # 104)**

Figure 39. Mass 3-2-a elevation and isometric rendering.

Mass 3-2-b Elevations

Adobe House



Commentary Responding to the desire for privacy plus the need for insulation against summer heat and winter cold, these buildings exhibit a very low proportion of venting to wall surface. For the front elevation, the proportion of window to wall is just 7.8 %; for the rear (with door only the figure is 5.9 %; for both side elevations, the proportion of window to wall is just 6.1 %.

Figure 40. Mass 3-2-b elevations.

Mass 3-3-a Floor Plan

Adobe House

Commentary

Walls appear extraordinarily thick, relative to room sizes, but are at scale. These very thick walls are used for strength and for insulation in the arid climates where found (the Middle East, for example; North American examples occur in Mexico and the US Southwest).

Windows are few, or nonexistent where houses have open courtyards, located either behind front and rear exterior walls, or as an atrium near the center of the house.

Floor Plan of Typical Adobe Dwelling in Iran

Thick adobe walls are used for strength and insulation

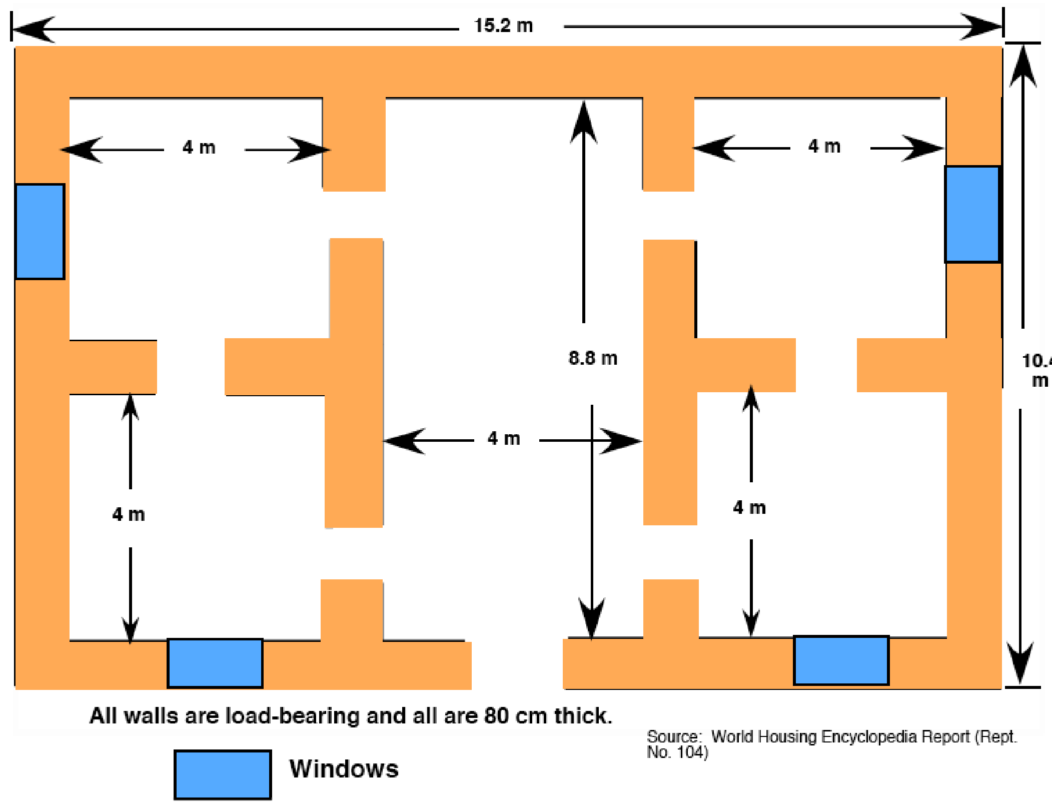


Figure 41. Mass 3-3-a floor plan.

Mass 3-4-a Construction

Adobe House

Commentary

A triple adobe brick — using dimensions 40 x 26 x 10 cm — results in a wall that uses both three widths and two lengths to achieve a total width of 80 cm. To construct a wall of the same width using standard American bricks would require a 6 brick thickness.

This thickness gives structural strength and mitigation of extreme diurnal and seasonal temperature fluctuations.

Adobe walls ordinarily use alternate courses (English Bond) to provide strength.

Example of an Adobe Wall (one course): from Iran

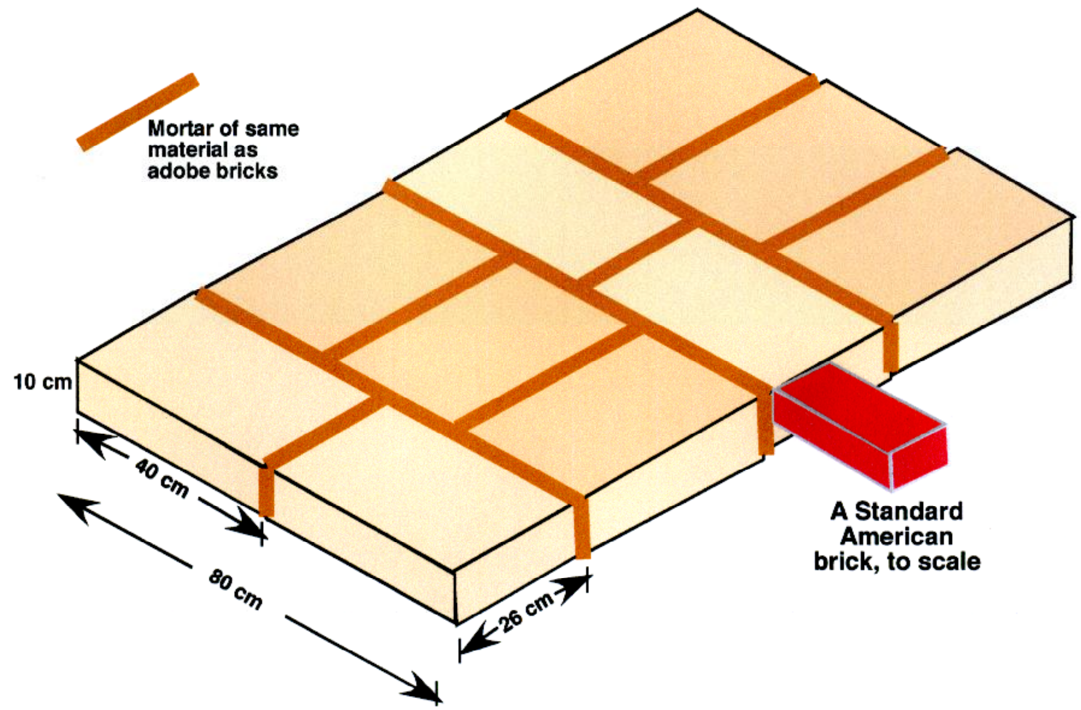
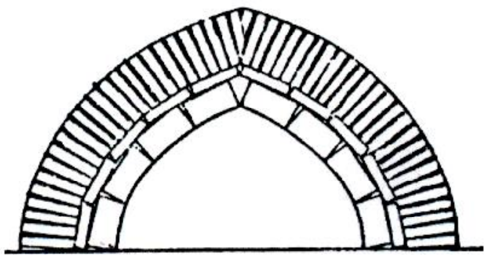


Figure 42. Mass 3-4-a construction.

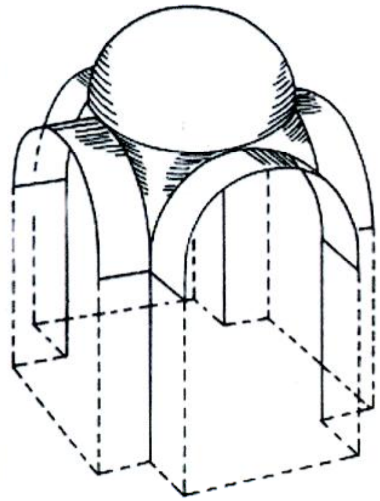
Mass 3-4-b Construction Method

Adobe House

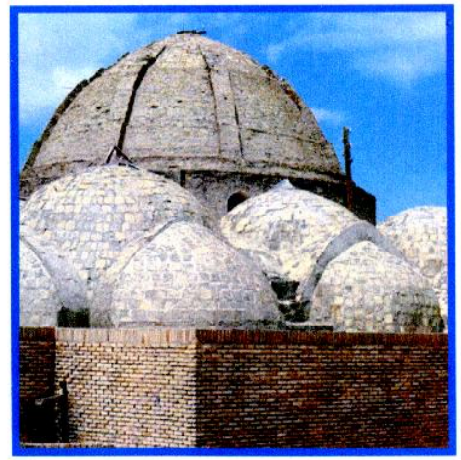
Simple Islamic Arch



Vaults and a Dome



Example Large and Small Domes in a Suq (Market Place)



Commentary

The adobe house (see photo on Mass 3-1) has both an arch for the center rooms and domes for each of the small 4 x 4 meter rooms. They were constructed in the way illustrated above. The basic form is the arch, used throughout time for many forms of construction, e.g., bridges, and given regional character, e.g., the Roman arch, in many parts of the world. The arch is then expanded into linear shaped vaults, or the gores are brought together to form domes. These methods succeed in enclosing space through the device of a brick roof.

Figure 43. Mass 3-4-b construction method.

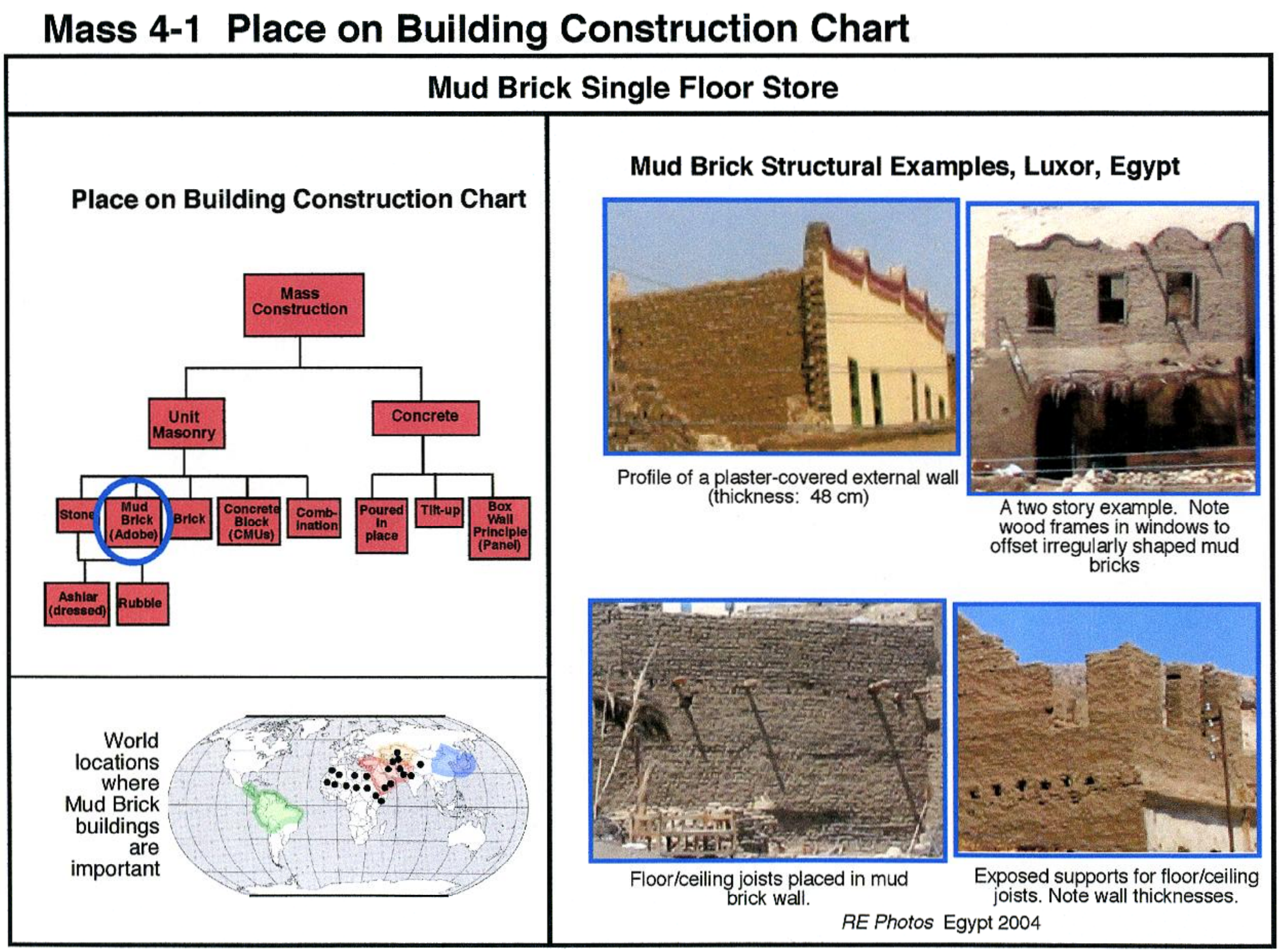


Figure 44. Mass 4-1 place on building construction chart.

Mass 4-2 Elevations

Mud Brick Single Floor Store

Commentary

Even simple mud brick structures display certain required features: (1) mud bricks are laid upon a plinth of concrete to reduce water damage from the bottom; (2) lintels, usually of wood but may be stone or concrete, support the weight lost when doors and windows are placed in a wall; (3) joist poles extruding through the side wall to hold the floor/ceiling material of reeds, brush, and mud; and (4) window panes are small, being less expensive to make and maintain than larger sheets of glass.

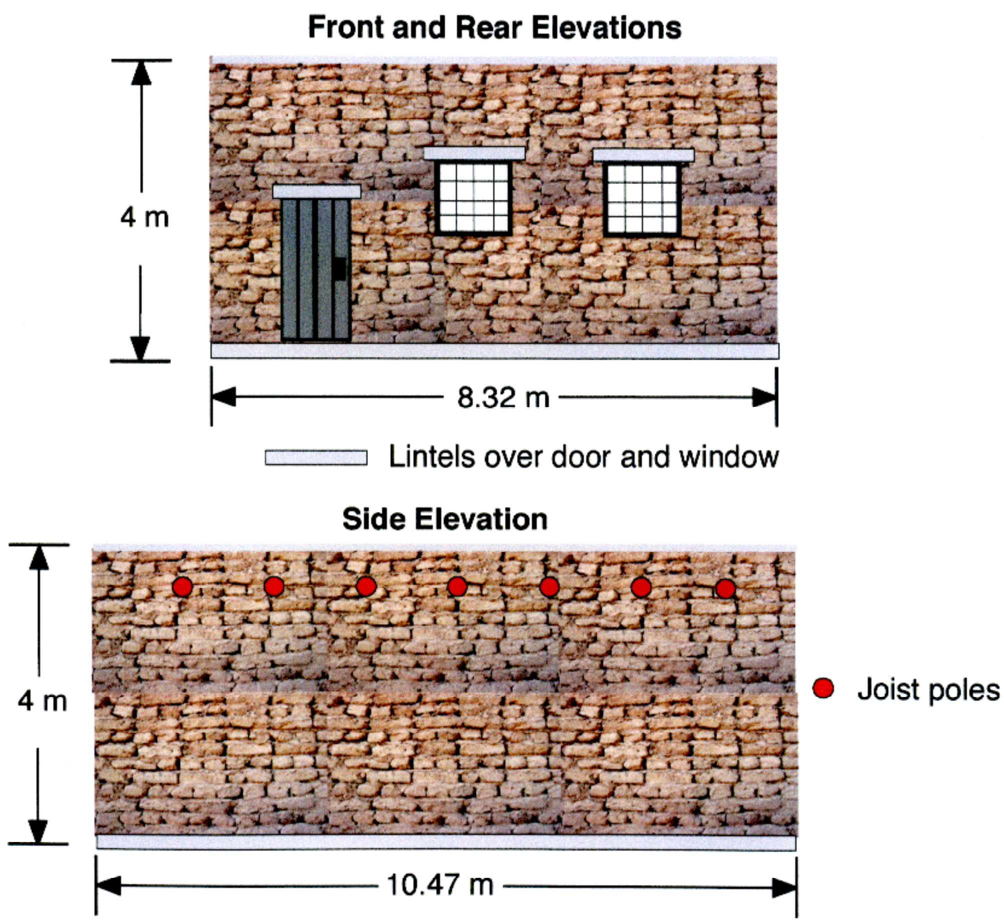


Figure 45. Mass 4-2 elevations.

Mass 4-3-a Floor Plan

Mud Brick Single Floor Store

Commentary

This is a single story mud brick building. Its narrow width (8.32 meters) accommodates the pole joists (see Plate Mass 4-4-d) without additional interior support. Space is divided into two equal parts. The front, facing the street, serves as a retail outlet; the product sold is fabricated in the rear section, which also serves as storage for materials and products.

Load-bearing exterior walls are 48 cm thick (a combination of a 30 cm stretcher and a 15 cm header plus 3 cm of mortar). The interior wall is also load-bearing but only one withe thick (15 cm).

Ground Floor

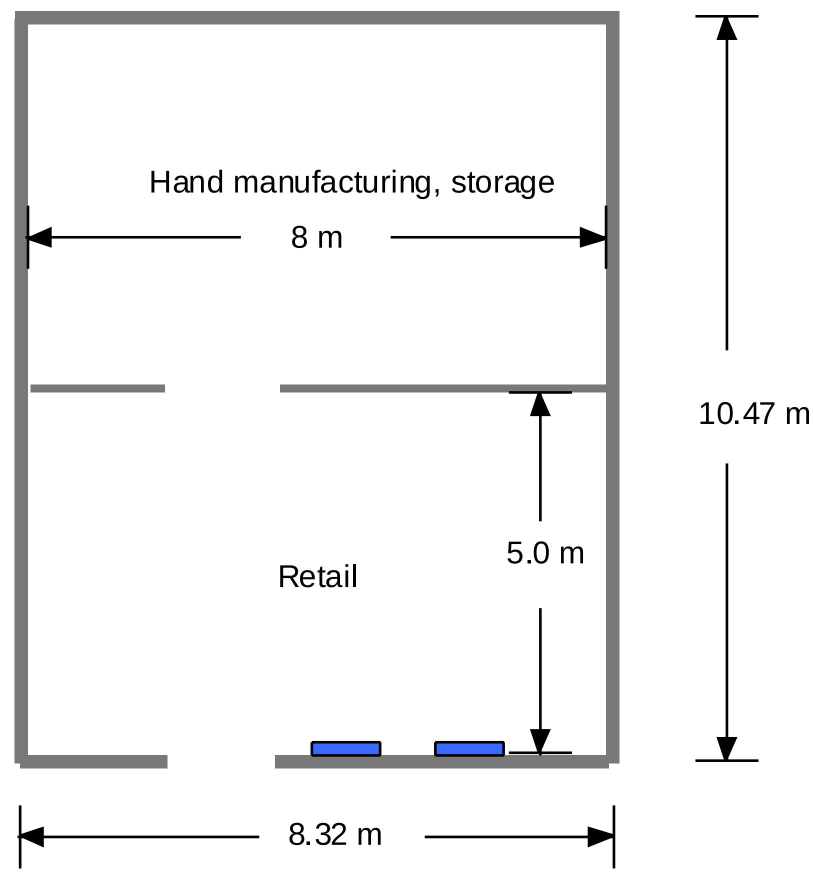


Figure 46. Mass 4-3-a floor plan.

Mass 4-4-a Construction: Building Materials

Mud Brick Single Floor Store

Mud Brick Examples: Egypt 2004

A Quadruple Mud Brick Wall

Close-up of Mud Brick Wall
Using English Bonding

Straw in Mud Brick, added for Strength

Commentary

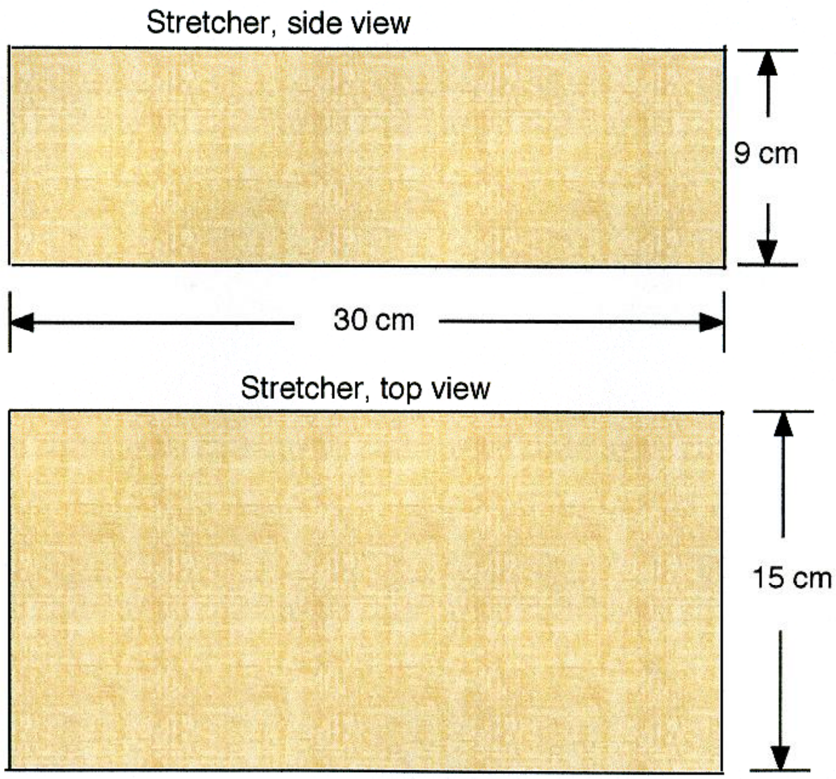
The character of mud brick is revealed here. Bricks are uneven in shape, and courses are not laid neatly as is the practice with kiln-dried brick. However, English bond (alternate courses of stretchers and headers) is commonly used. Straw, used to strengthen the clay, is exposed in many instances. This quadruple brick wall (in Luxor, Egypt) is about 66 cm in thickness. *RE Photos 2004*.

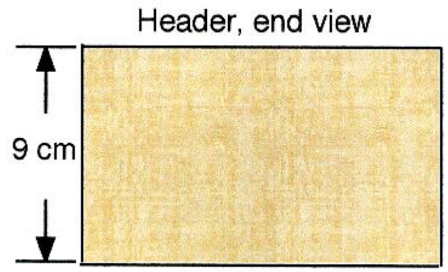
Figure 47. Mass 4-4-a construction: building materials.

Mass 4-4-b Construction: Materials

Mud Brick Single Floor Store

Mud Brick Dimensions





Commentary

Dimensions shown here are figures aggregated from references in several parts of the world; local dimensions vary with some stretchers reaching 40 cm in length and 20 cm in width. Heights are sometimes thicker than 9 cm. For targeting purposes, the wall thicknesses that result from the dimensions shown here would be 48 cm (including mortar) for a triple brick wall, and 66 cm for a quadruple brick wall (see photos taken in Egypt).

Note: The term slab is often used in the literature, rather than brick, indicating the flat-like character of each piece.

Figure 48. Mass 4-4-b construction: materials.

Mass 4-4-c Construction: Materials

Mud Brick Single Floor Store

Commentary

Two stages of mud brick making are visible here. In the upper part of the group, near the worker, bricks are in an advanced stage of drying: those in the lower area have apparently just been formed and are now beginning the drying process. That mud bricks are larger than kiln dried clay bricks is also evident. The latter are designed so that a mason can span the width of the header (some 4 inches or so) with one hand to place the brick onto the wall being built, while keeping the trowel in the other hand. Mud bricks are definitely too wide to use this technique and must be placed with two hands.

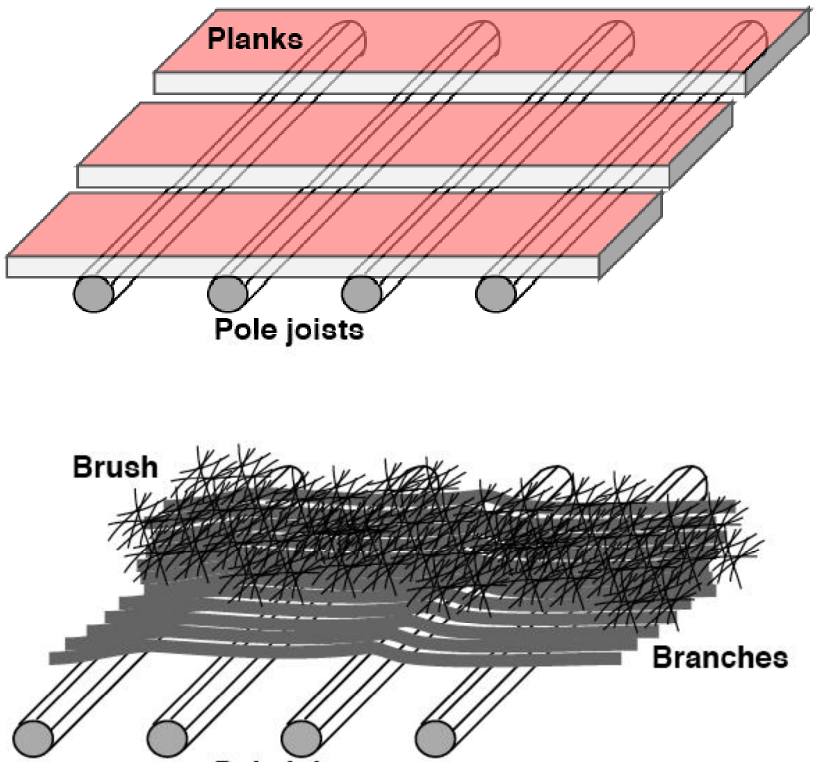
Freshly Made Mud Bricks Drying in the Sun

Figure 49. Mass 4-4-c construction: materials.

Mass 4-4-d Construction: Roof Materials

Mud Brick Single Floor Store

Floor/ceiling and Roof Details



Commentary
Mud brick construction uses local wood materials for ceiling/floors (for multi-story buildings); planks are placed across pole joists. Roofs also use pole joists but these are covered first with irregular branches, then brush. These are then plastered with mud to keep out the weather. Flat roofs are the mode in the dry climate areas where mud brick construction is common; the roof is often used for sleeping on hot nights.

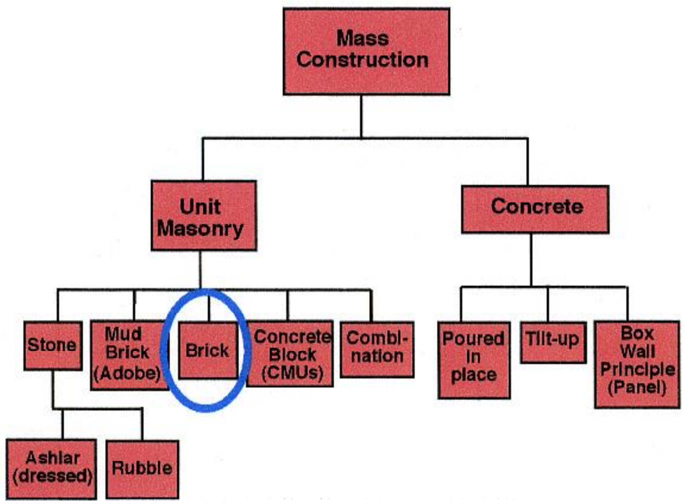
Branches placed cross-wise to joists.

Figure 50. Mass 4-4-d construction: roof materials.

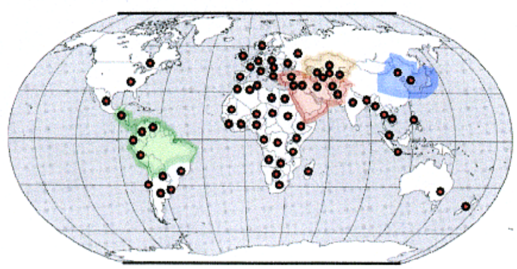
Mass 5-1 Place on Building Construction Chart

Triple Brick House

Placement on Building Construction Chart



World locations where Brick Buildings are important



International Example

RE photo.

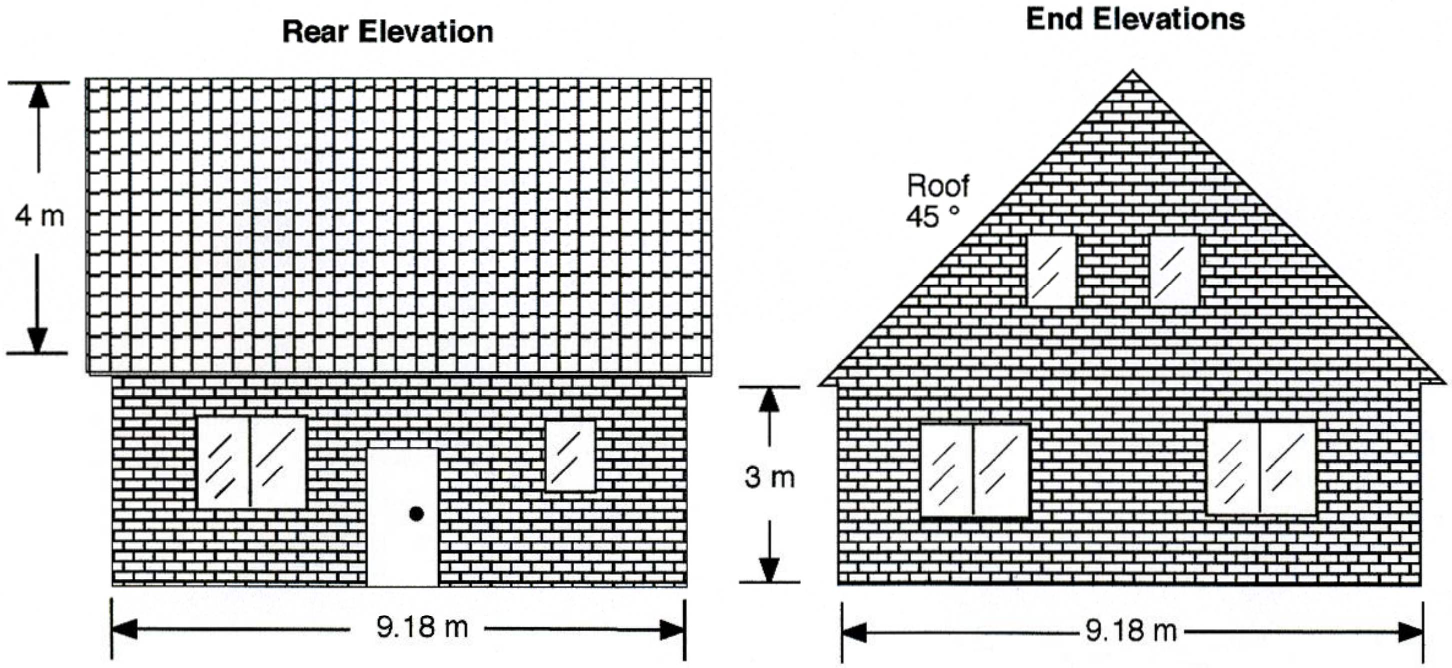
Several pertinent characteristics and features of triple brick houses are seen in this example. The windowless corners, where the two planes meet, are the strongest structural elements. The windows, to make minimal the loss of integrity, are aligned vertically. Giving further support are the stone lintels bridging the tops of each window. The Flemish pattern (alternate headers and stretchers on each course) of brick bonding is employed indicating triple brick construction for both floors.

Figure 51. Mass 5-1 place on building construction chart.

Mass 5-2 Elevations

Triple Brick House

Elevations: Rear and End



Commentary	These elevations relate to the floor plans of ground and upper stories. Venting forms but a small proportion of total wall space, as is keeping with mass construction where windows and doors are at the expense of wall strength; to replace this strength, lintels are required above windows and doors (even though their presence is normally covered by stucco or other wall cover). Roof pitch is a simple 45 degrees. Floor height is the standard 3 meters.

Figure 52. Mass 5-2 elevations.

Mass 5-3-a Floor Plan

Triple Brick House

Floor Plan (Ground floor)

Commentary

This floor plan is a generic composite, drawn from observed small houses in various countries. It takes into consideration human size dimensions for rooms, doorways, and windows based on standard sizes of furniture and living space needs.

Room dimensions meet common daily needs: living and family eating areas are joined; the dining area can be served by the kitchen; utility needs are met; the kitchen is of modest but adequate size. Each room is vented; window width ranges from sub meter to 1 1/2 meters.

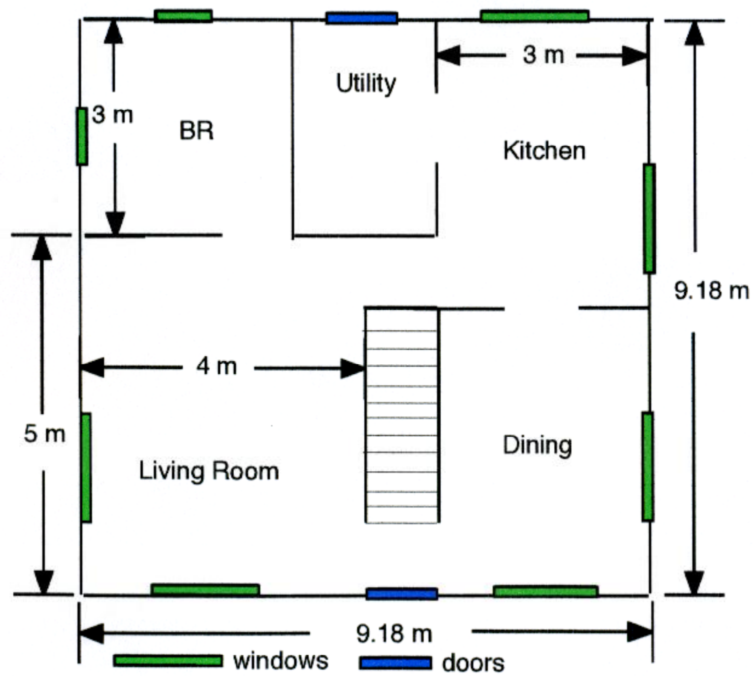


Figure 53. Mass 5-3-a floor plan.

Mass 5-3-b   Floor Plan

Triple Brick House

Floor Plan: Upper Floor

Commentary

The upper floor of this one and a half story house has a smaller footprint than the ground floor owing to the slope of the roof. It provides the bedrooms (3) and the bathroom for the house (water pipes are directly above those for the kitchen). The stairs from the ground floor give access.

Strengthening of the structure is achieved through the interior load-bearing walls that extend upward from the ground floor.

The only venting is through the end walls, although in Europe, openable roof skylights to provide extra lighting and ventilation are common.

Upper Story Floor Plan

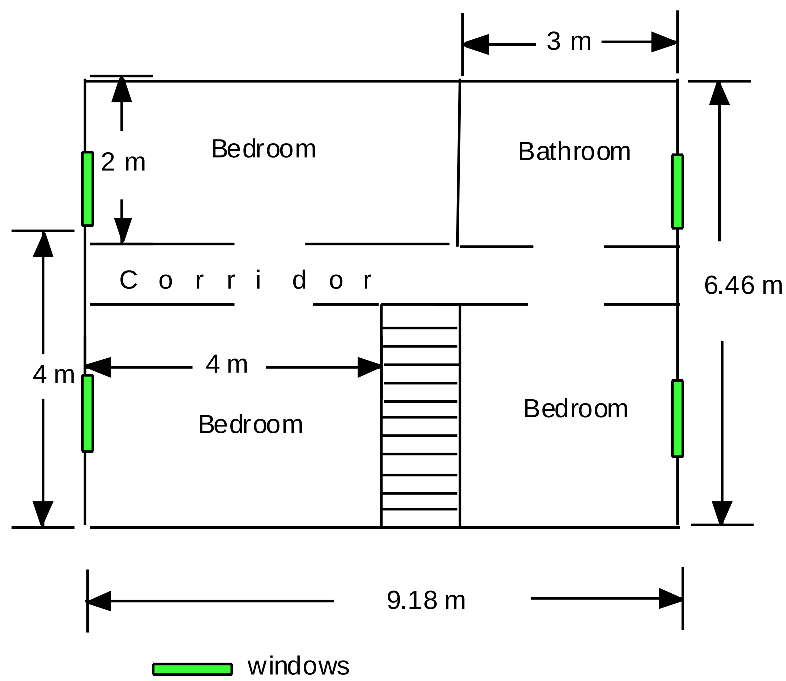


Figure 54. Mass 5-3-b floor plan.

Mass 5-4-a Construction

Triple Brick House

Ground floor

Commentary

Principal structural strength is based on triple brick (36 cm thick) perimeter walls. These are braced by interior load-bearing double brick (23 cm) walls. Use of these interior load-bearing walls allows ceiling/floor joists ranging from 2 to 4 meters in length.

Door openings are placed in the interior walls to provide doorways between rooms.

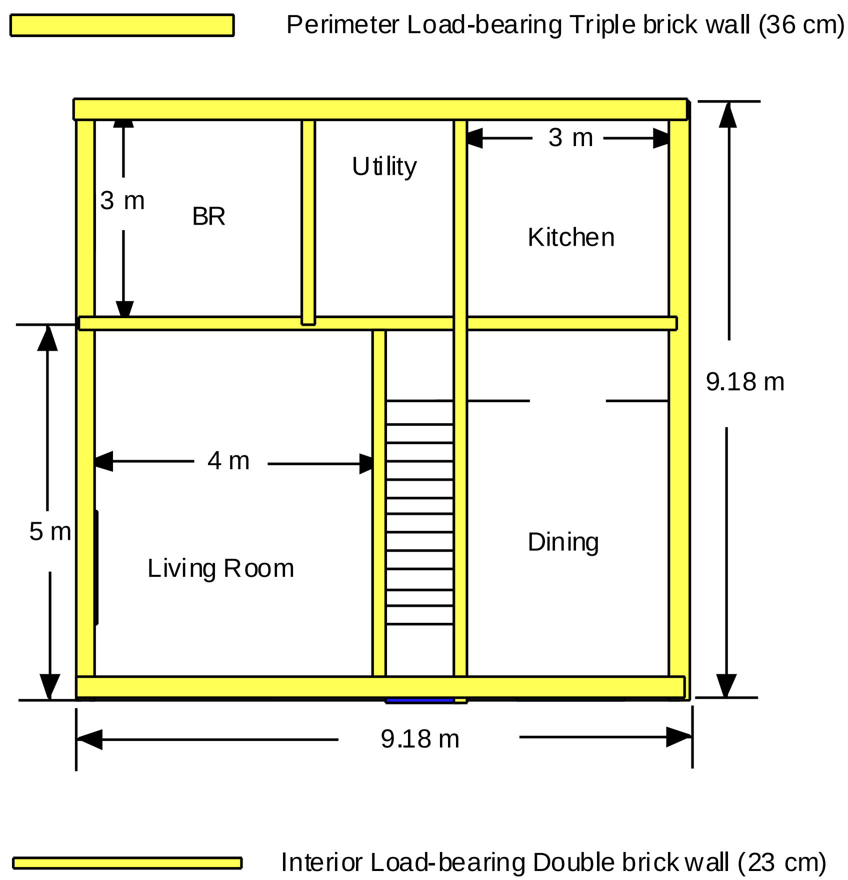


Figure 55. Mass 5-4-a construction.

Mass 5-4-b Construction

Triple Brick House

Structure on Upper Floor

Commentary

Interior load-bearing walls and exterior load-bearing walls project upward from the ground floor.

Upper Story Floor Plan

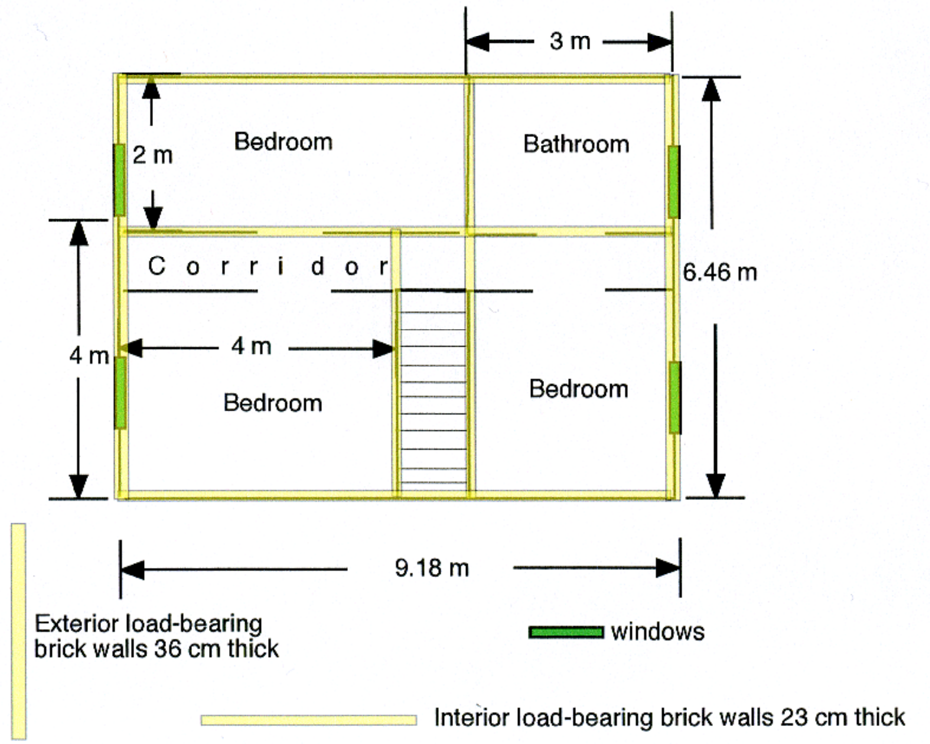


Figure 56. Mass 5-4-b construction.

Mass 5-4-c Construction (Brick Courses)

Triple Brick House

Construction: Triple Brick load-bearing Walls

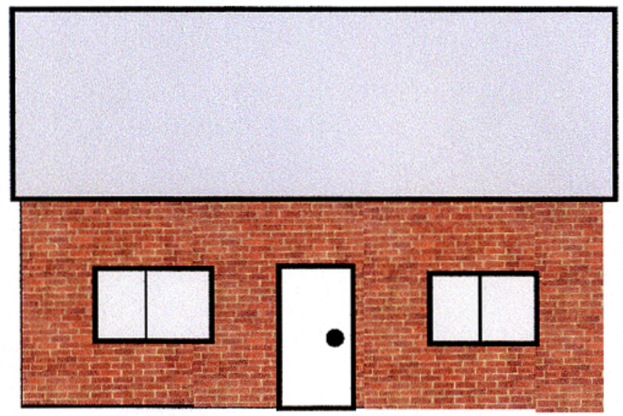
Commentary

This building employs the very common method of forming a load-bearing brick wall, namely use of Triple Brick, sufficient in strength for a single story or two story building. It is formed of one stretcher and one header. This arrangement manifests itself in the English bond (alternate courses of headers and stretchers) illustrated here. This combination of bricks and intervening mortar yields a total wall thickness of 36 cm.

While well mortared brick can withstand the elements, the common practice is to cover the brick with stucco.

This front elevation shows the windows for the living room the left and the dining room on the right, with the front door in the middle.

Front Elevation: Brick



English Bond (Alternate Course)

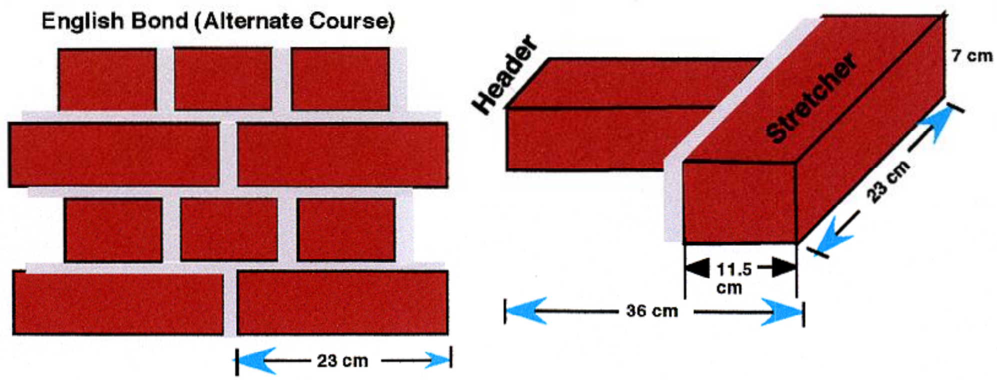
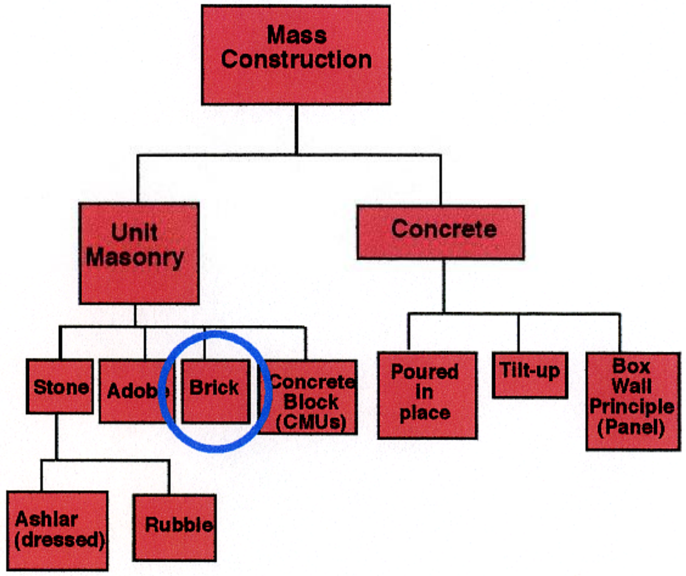


Figure 57. Mass 5-4-c construction (brick courses).

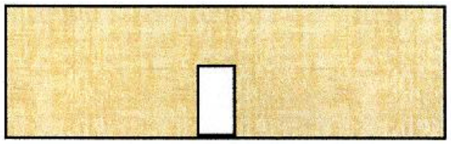
Mass 6-1 Place on Building Construction Chart

Triple Brick Middle Eastern House

Place on Building Construction Chart

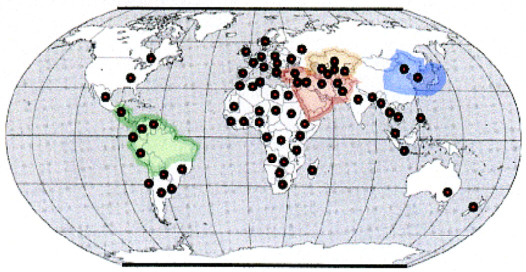


Simple Elevation



View from the street is of a blank, usually plastered, wall punctuated only by a small doorway into the main open courtyard.

World locations where Brick Buildings are important



Commentary

The Arab Muslim house shown here is constructed of load-bearing triple brick walls. An Iranian brick size of 55 x 110 x 220 mm, considering 15 mm mortar thickness, produces a wall 34.5 cm thick. An old Israeli brick 25 x 12 cm plus 1.5 cm mortar yields a wall 38.5 cm thick (see 6-4-b).

Figure 58. Mass 6-1 place on building construction chart.

Mass 6-2 Elevations

Triple Brick Middle Eastern House

Commentary

With the only venting on the exterior walls being doors, the main entrance in the center of the front elevation and a smaller (women's) door at the side rear, this house manifests the wish for privacy from the outside world. The blank walls give no indication of the function of rooms behind them.

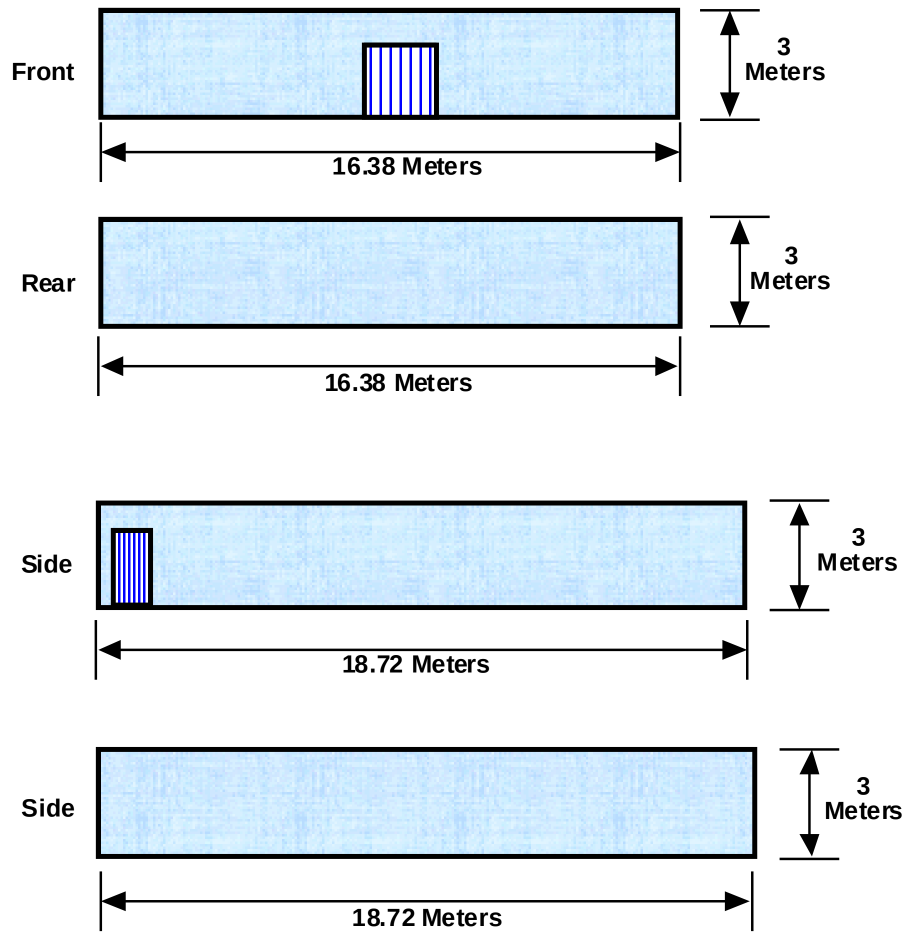


Figure 59. Mass 6-2 elevations.

Mass 6-3-a   Floor Plan

Triple Brick Middle Eastern House

Commentary

Mass construction (triple brick in this case) Arab Muslim houses share several characteristics:

(1) All walls are same thickness (in part because of the open courtyards)

(2) House plan shows Muslim effects in separating male from female areas: front part is male, rear is female; privacy goals are supreme (no external windows); house has no articulating corridors

Exterior and Interior Walls are All Load-Bearing: Thickness is 34.5 cm.

The roof is reinforced concrete 10 cm thick.

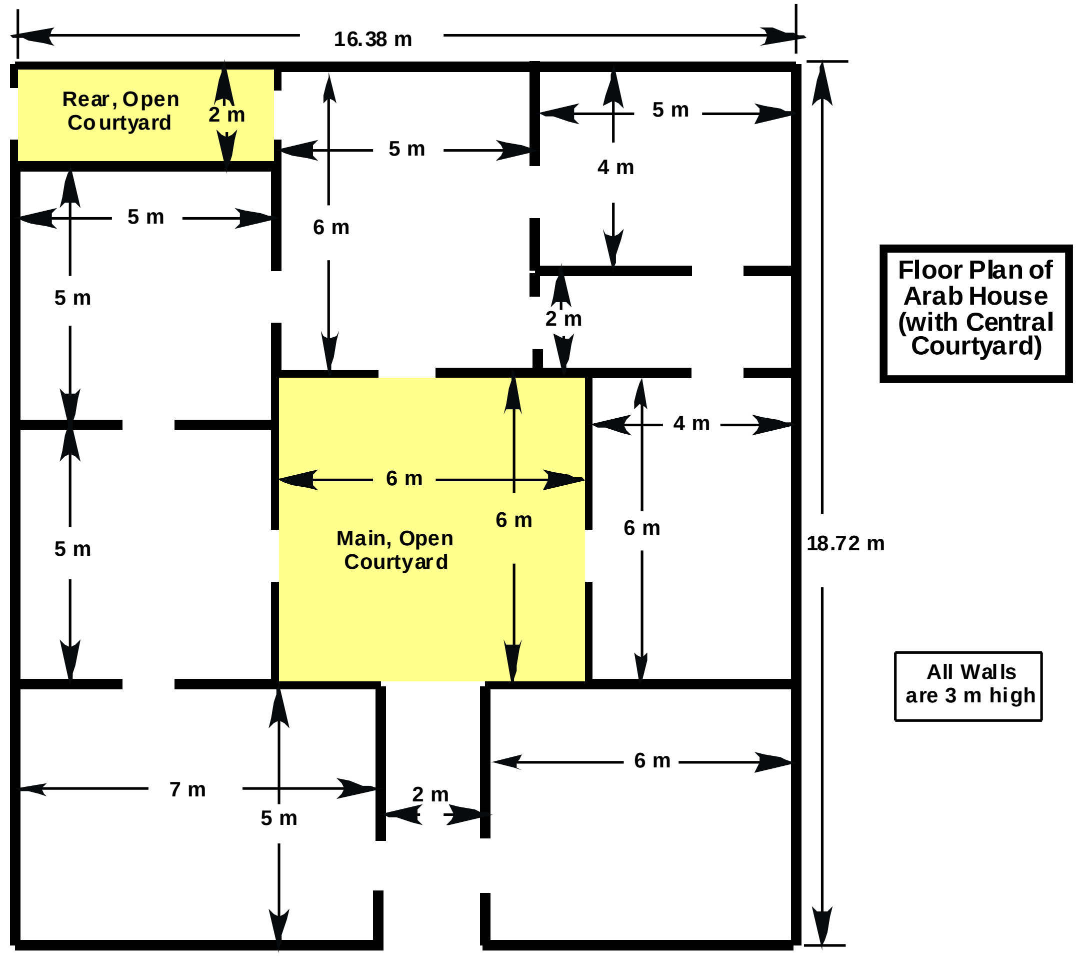


Figure 60. Mass 6-3-a floor plan.

Mass 6-3-b Isometric Floor Plan

Triple Brick Middle Eastern House

Commentary

This 45° isometric rendering of the floor plan aids understanding the spatial arrangements within the structure and the articulation with the central courtyard.

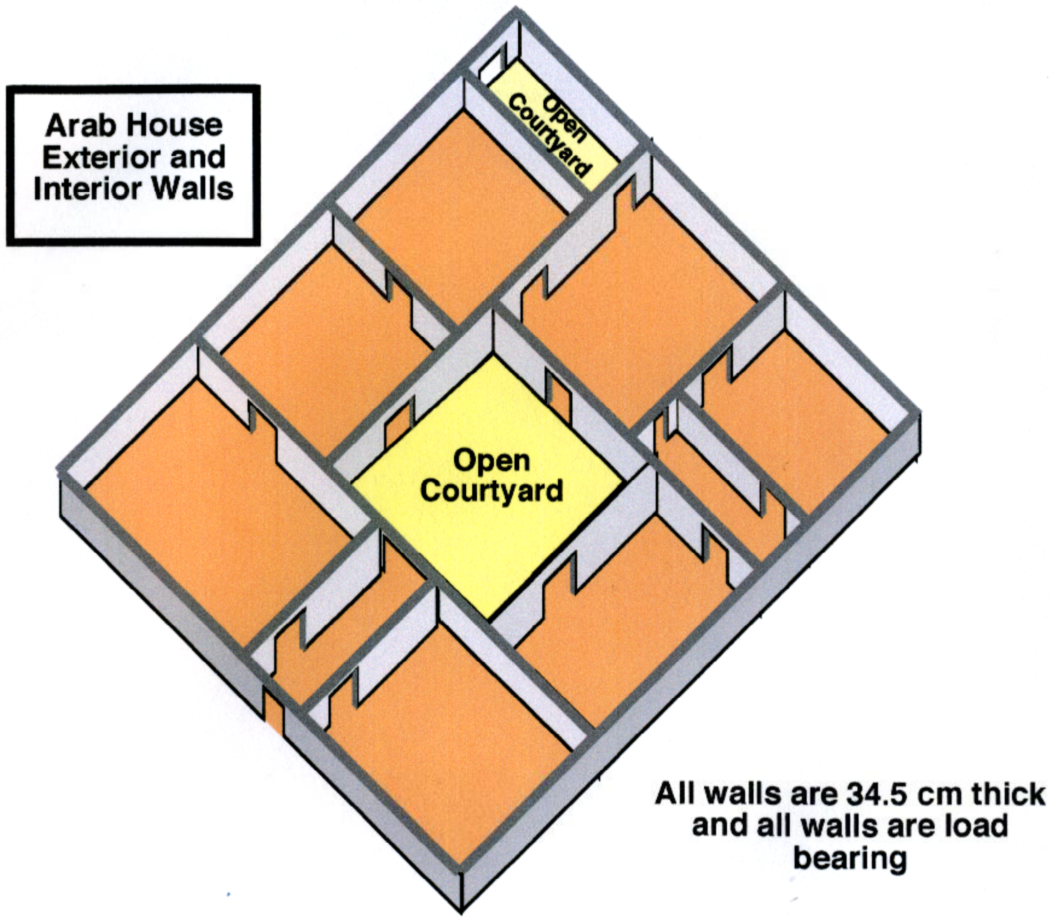


Figure 61. Mass 6-3-b isometric floor plan.

Mass 6-3-c Isometric Floor Plan

Triple Brick Middle Eastern House

Commentary

This 45° isometric rendering of the floor plan aids understanding the spatial arrangements within the structure and the articulation with the central courtyard.

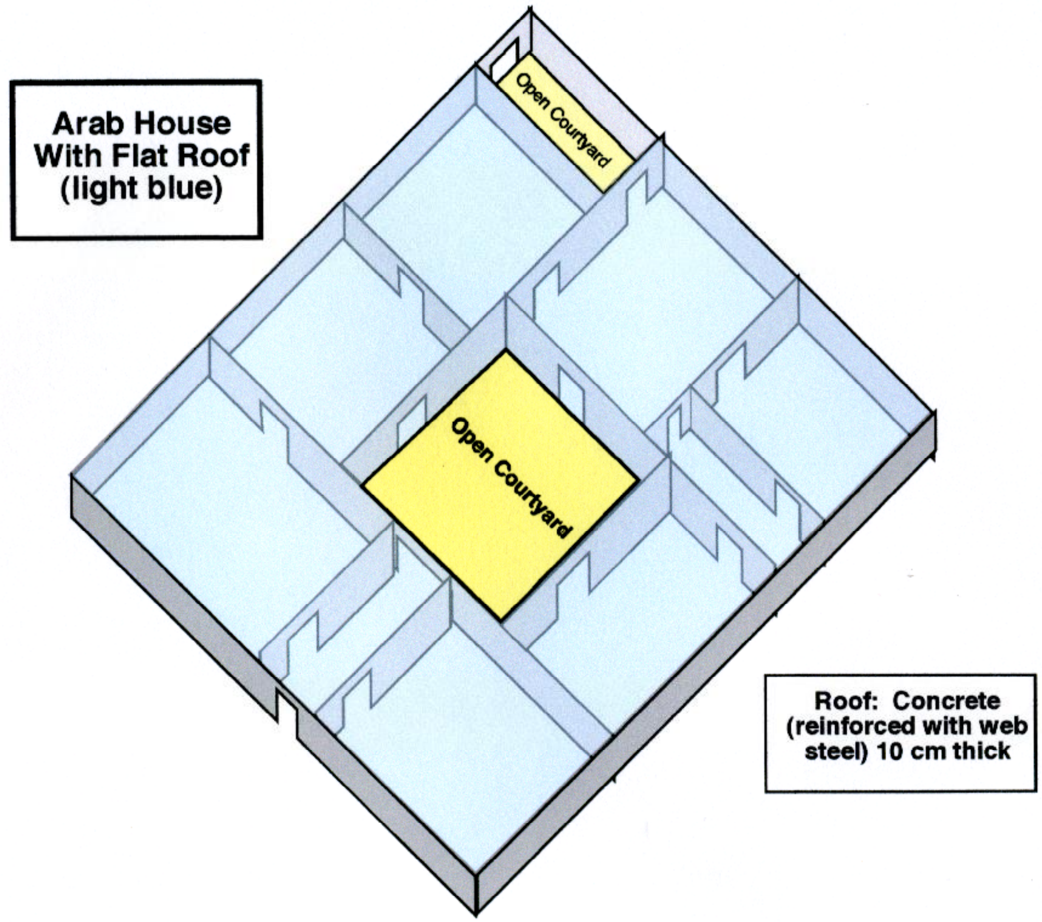


Figure 62. Mass 6-3-c isometric floor plan.

Mass 6-4-a Construction

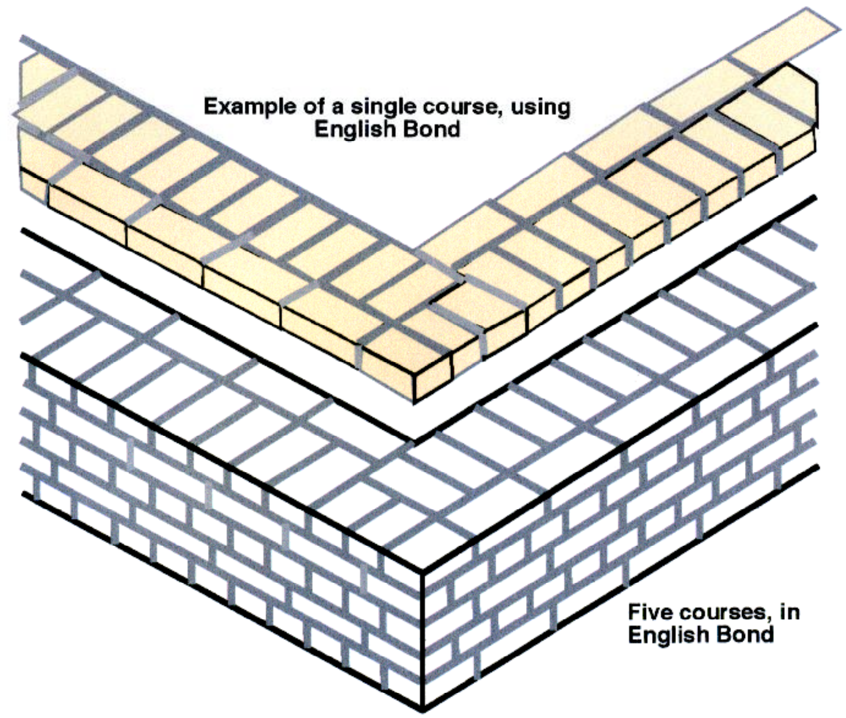
Triple Brick Middle Eastern House

Construction Method and Dimensions

Commentary

Bricks used in the Arab Muslim world, although a single standard is not found, are somewhat larger in all dimensions than the standard American brick (8 x 4 x 2.5 inches), or in metric measurement (to nearest mm), 200 mm x 100 mm x 60 mm. Brick dimensions on the drawing are those reported for a typical building in Iran. An old Israeli brick (shown on following plate) is a little larger.

Compressive strength of brick also varies. A range of 101 kg/cm^2 to 152 kg/cm^2 is found.



Brick size: 55 x 110 x 220 mm. Therefore, "work size" (includes mortar) making wall thickness 220 + 110 + 15 mm mortar = 345 mm (34.5 cm).

Figure 63. Mass 6-4-a construction.

Mass 6-4-b Construction

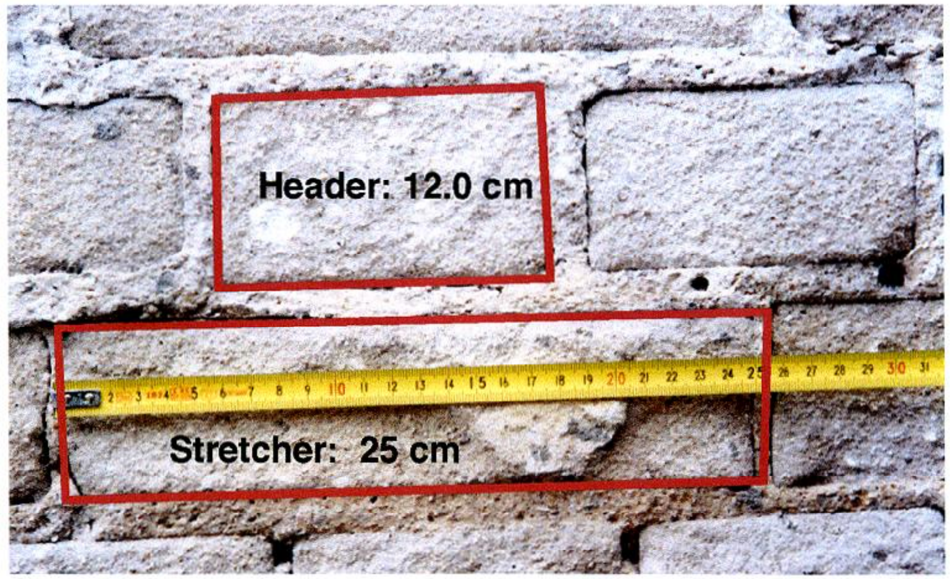
Triple Brick Middle Eastern House

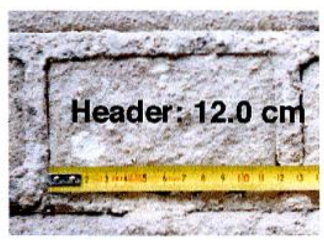
Construction Method and Dimensions

Commentary

This segment of a brick wall (of an old building in Tel Aviv, as photographed and measured in 1999 shows bricks to have: headers of 12.0 cm; and stretchers of 25.0 cm. The wall was laid using English Bond (alternate courses).

Wall thickness, with such a bonding pattern, would be 12 cm plus 25 cm plus 2 cm of mortar to equal 39 cm (or aprx. 15 inches). A triple brick wall made with US standard brick dimensions would be about 12 1/4 inches.





English Bond

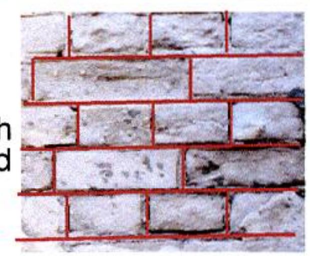
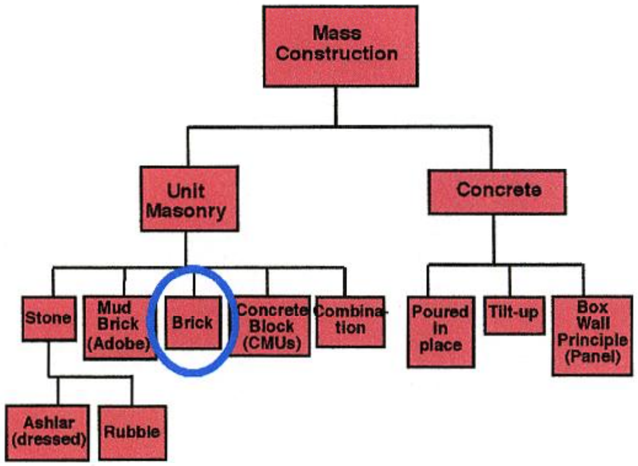


Figure 64. Mass 6-4-b construction.

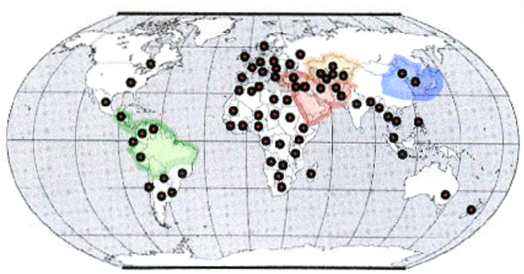
Mass 7-1 Place on Building Construction Chart

Brick Row House

Place on Building Construction Chart



World locations where Brick Buildings are important



International Example

RE photo.

Row houses, such as this example in England, have been a traditional type of housing for a long time. Accordingly, there are many extant examples. Chimneys indicate common wall construction (as opposed to each unit being built separately), and thus load-bearing separating walls are as thin as possible. In the UK, these walls reach through the attic to prevent spread of fire from unit to unit.

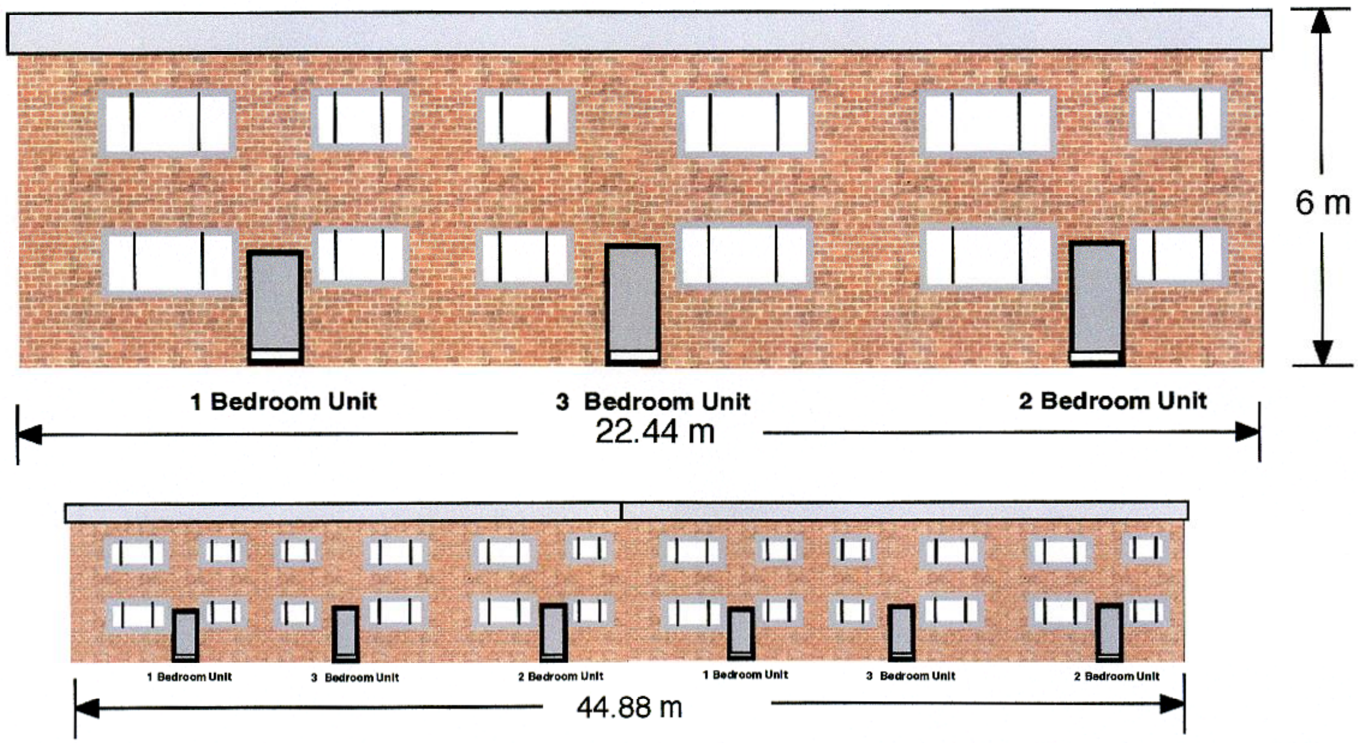
Figure 65. Mass 7-1 place on building construction chart.

Mass 7-2-a Elevation

Brick Row House

Elevations

Front Elevation



Commentary The upper graphic shows a three apartment segment of a long row house: the lower diagram puts two of these units together to simulate a typical case. Note low profile.

Figure 66. Mass 7-2-a elevation.

Mass 7-2-b Elevation

Brick Row House

Elevations

Commentary

Small windows at the rear of the building indicate the functions of the rooms served, i.e., bedrooms upstairs and the rear side of living rooms downstairs.

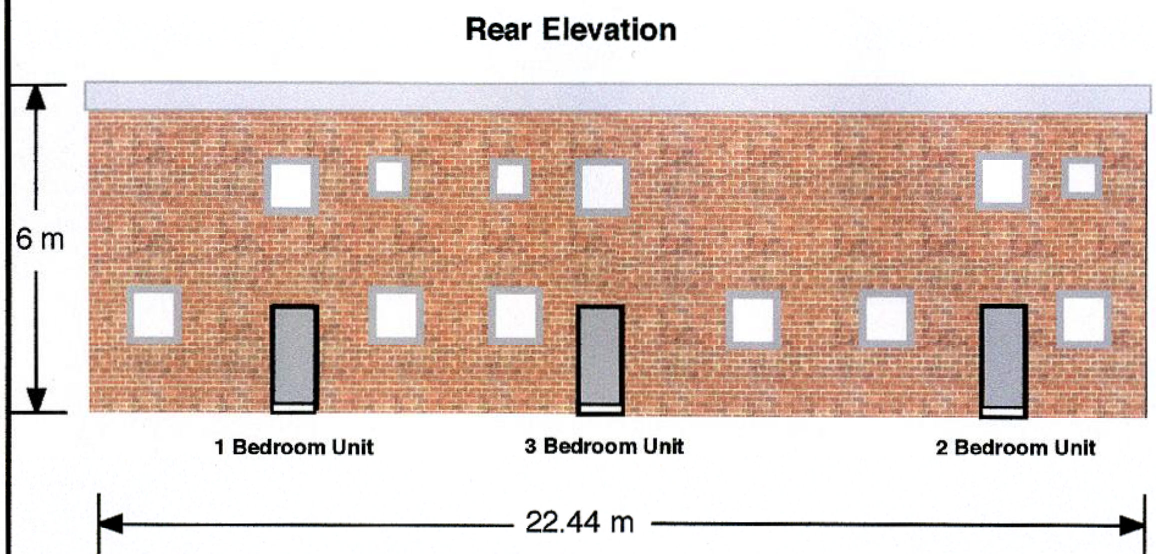


Figure 67. Mass 7-2-b elevation.

Mass 7-3-a Floor Plan

Brick Row House

Floor Plan

Commentary

As is common, multiple family dwellings offer various sized units. Here, we see a one bedroom unit, a two, and a three. Living areas of all are on the ground floor with bedrooms on the upper floor. Bathroom units on the upper floor align with kitchens to share water supply plumbing.

Ground and Upper Floor Plans

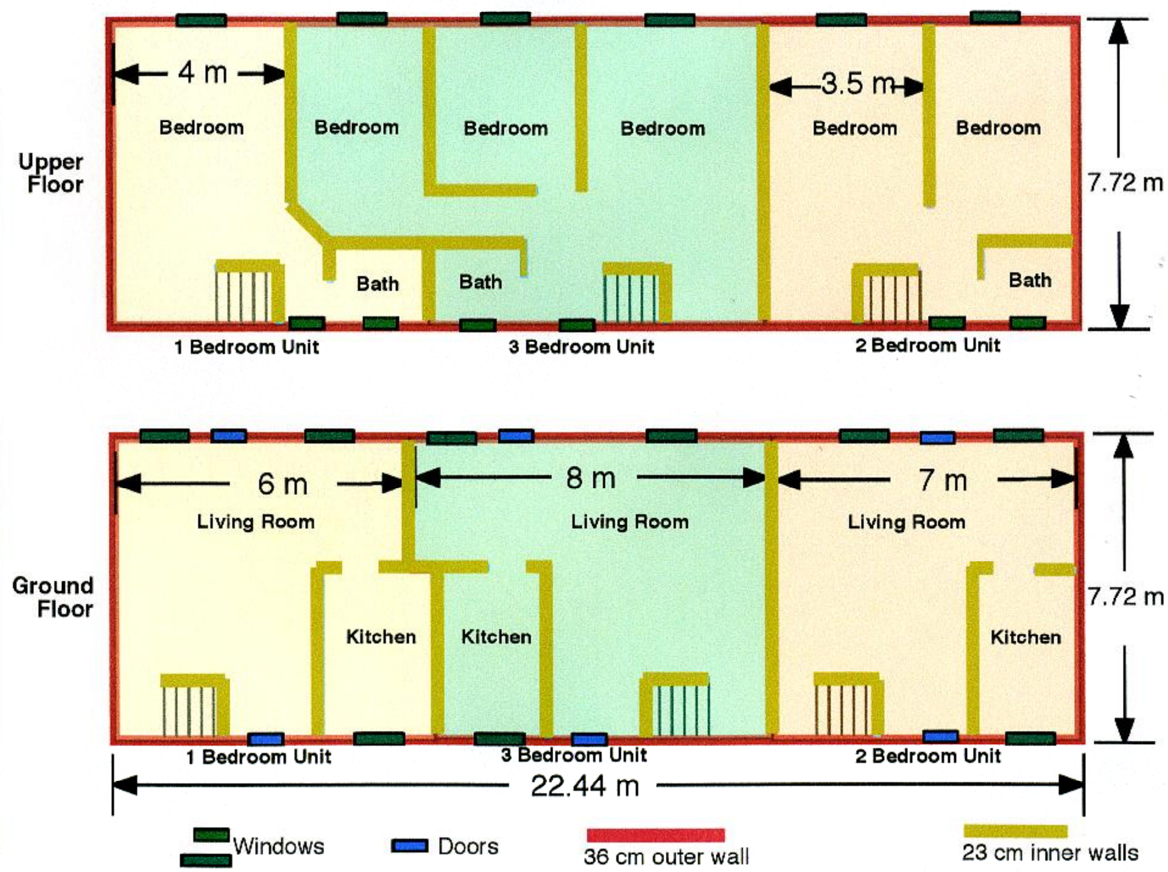


Figure 68. Mass 7-3-a floor plan.

Mass 7-3-b Isometric Floor Plan

Brick Row House

Commentary

This perspective view provides, in conjunction with the two dimensional floor plan, ready understanding of the building's spatial interior arrangement, and how rooms may be accessed by troops entering the building.

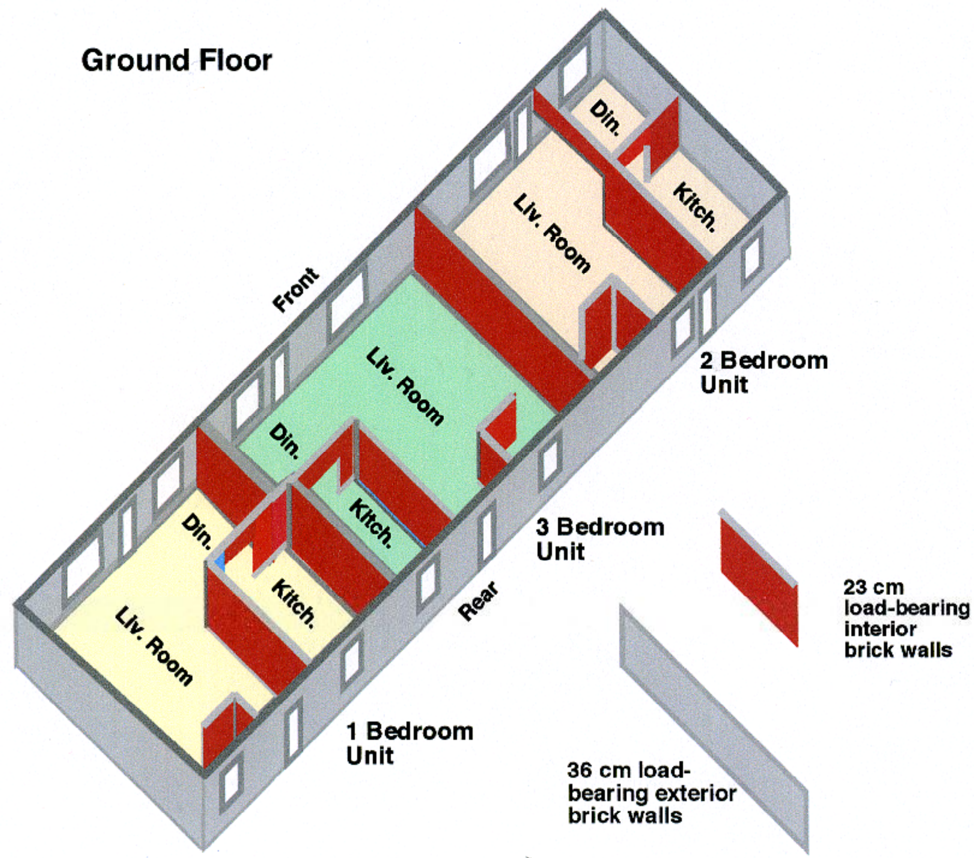


Figure 69. Mass 7-3-b floor plan.

Mass 7-3-c Isometric Floor Plan

Brick Row House

Commentary

This perspective view provides, in conjunction with the two dimensional floor plan, ready understanding of the building's spatial interior arrangement and how rooms may be accessed by troops entering the building.

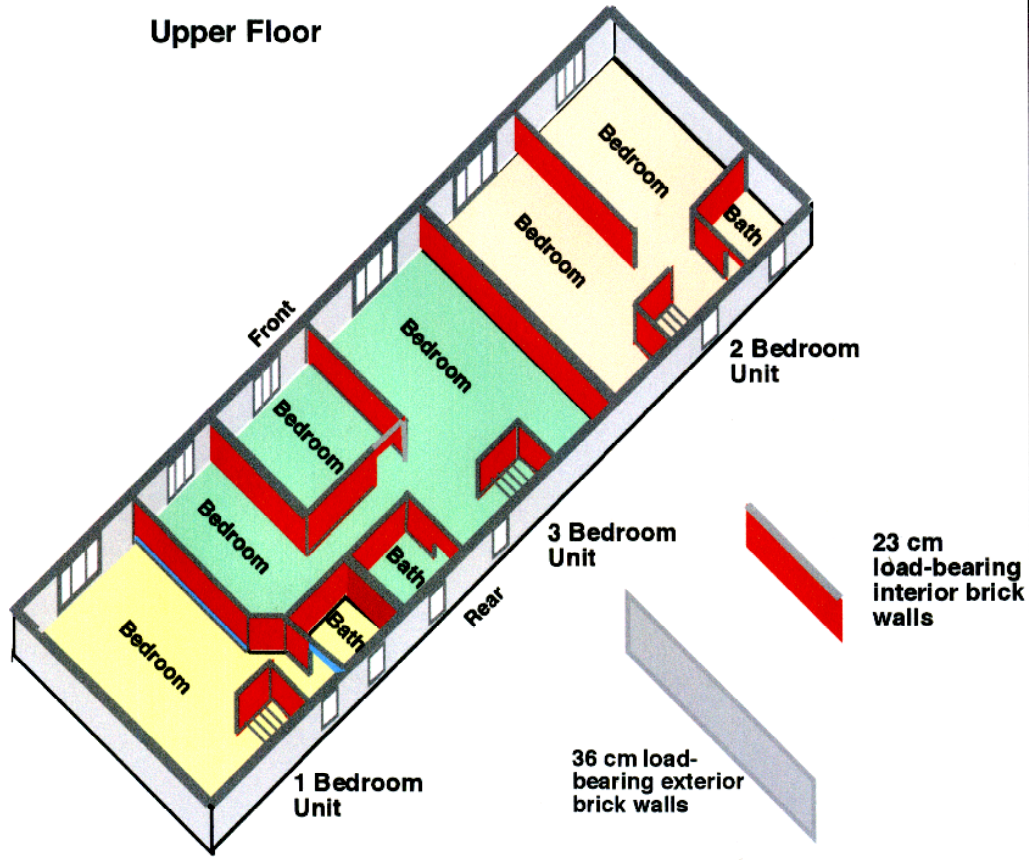


Figure 70. Mass 7-3-c isometric floor plan.

Mass 7-4 Construction

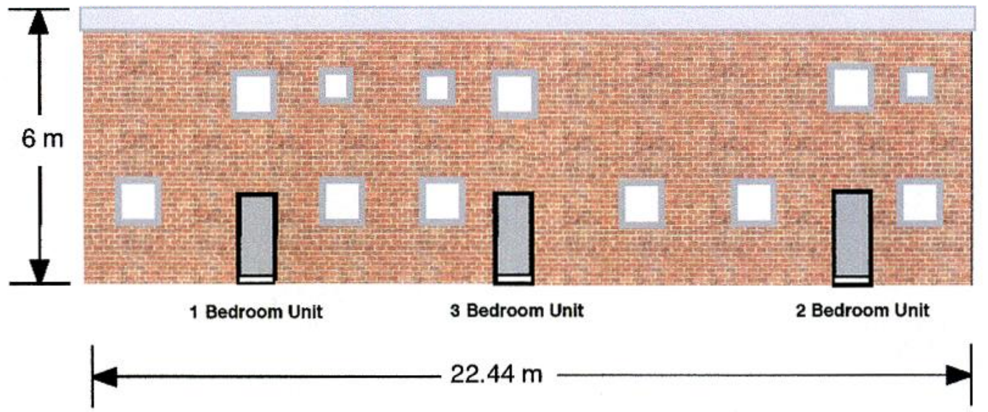
Triple Brick Row House

Construction: Triple Brick load-bearing Walls

Commentary

This building employs the very common method of forming a load-bearing brick wall, namely use of Triple Brick, sufficient in strength for a single story or two story building. It is formed of one stretcher and one header. This arrangement manifests itself in the English bond (alternate courses of headers and stretchers) illustrated here. This combination of bricks and intervening mortar yields a total wall thickness of 36 cm.

While well mortared brick can withstand the elements, the common practice is to cover the brick with stucco.



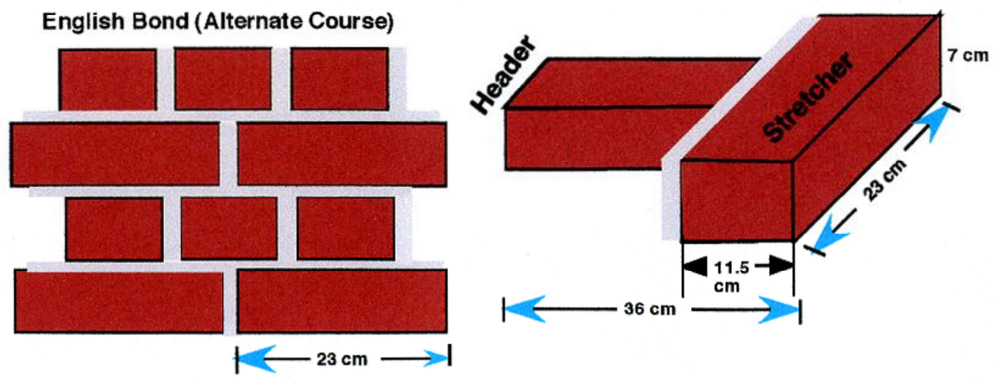
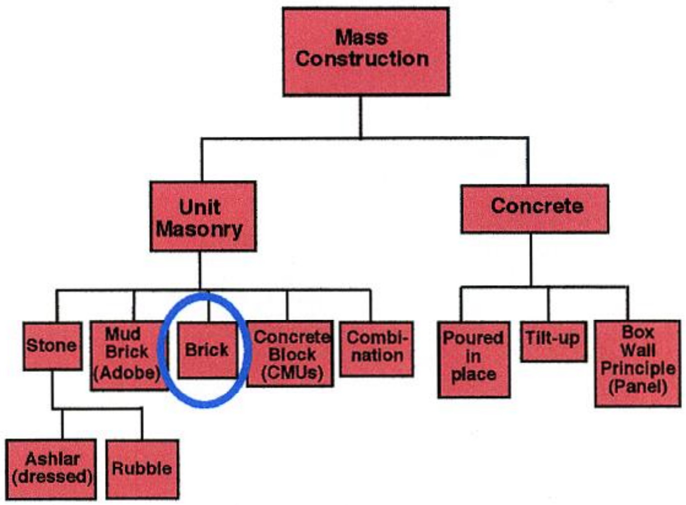


Figure 71. Mass 7-4 construction.

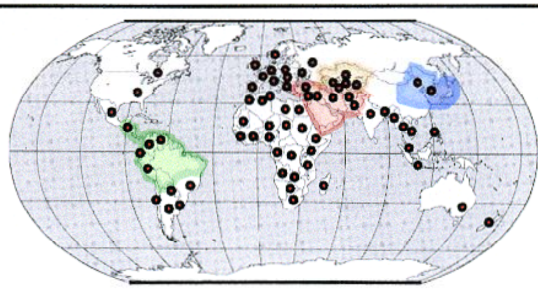
Mass 8-1 Place on Building Construction Chart

Brick Apartment Building, Stores Below

Place on Building Construction Chart



World locations where Brick Buildings are important



International Example

RE photo 2004

This elaborate, ornamented example (in Buda-pest, 2004) exemplifies the common features of such structures: the 1 x 1.5 meter windows of the upper floor are aligned (to keep minimal the loss of support in a brick building); the ground floor windows are larger to allow for display of retail goods. Styling is traditional with pediment on the ground floor, the shaft containing the apartments, and a decorative capital.

Figure 72. Mass 8-1 place on building construction chart.

Mass 8-2 Elevation

Brick Apartment Building, Stores Below

Front Elevation and Wall Thickness

Commentary

This building is archetypical of countless numbers seen in large European cities. Brick was used in their construction as it was the only possible means of constructing multi-story buildings prior to the end of the 19th century (and coinciding with a period of imperialism when demand for large buildings was great). Five stories was the practical limit before the advent of elevators. The use of brick meant that walls on the lower floors had to be very strong, which meant greater thickness of brick, to support the load above. Ground floor walls were commonly about 1 meter thick (8 bricks = 96 cm). As each building was constructed independently, adjacent buildings also abided by the thickness rules, thus yielding ground floor combined walls almost 2 meters thick.

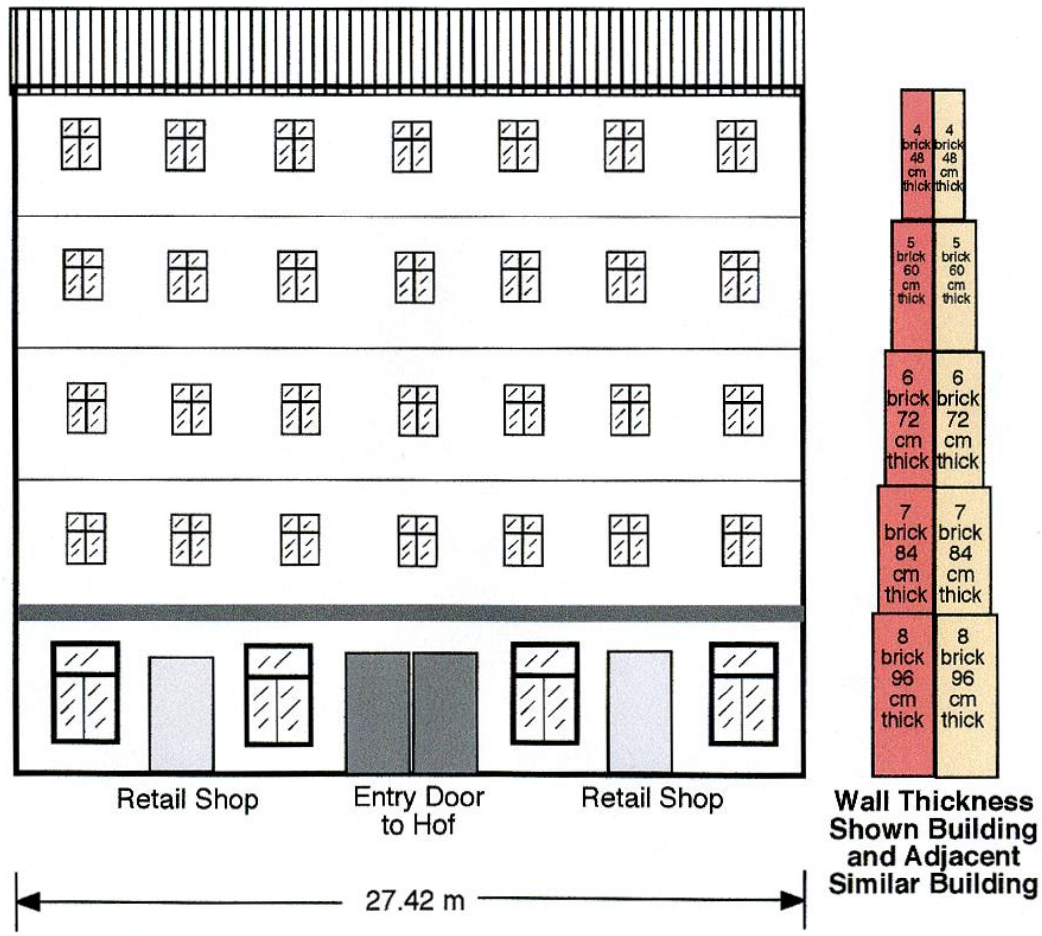


Figure 73. Mass 8-2 elevation.

Mass 8-3-a Floor Plan

Brick Hof-style Building: Stores Below, Apartments Above

Ground Floor Plan

Commentary

Buildings of this type, by definition, occupy expensive land in city center. As a result, considering that many potential customers pass the building daily, high-rent floor space fronting the sidewalk is best used for the profitable purveying of goods and services. Stores are common, as are restaurants and services. A passageway, at ground floor level, provides access to the hof from the sidewalk.

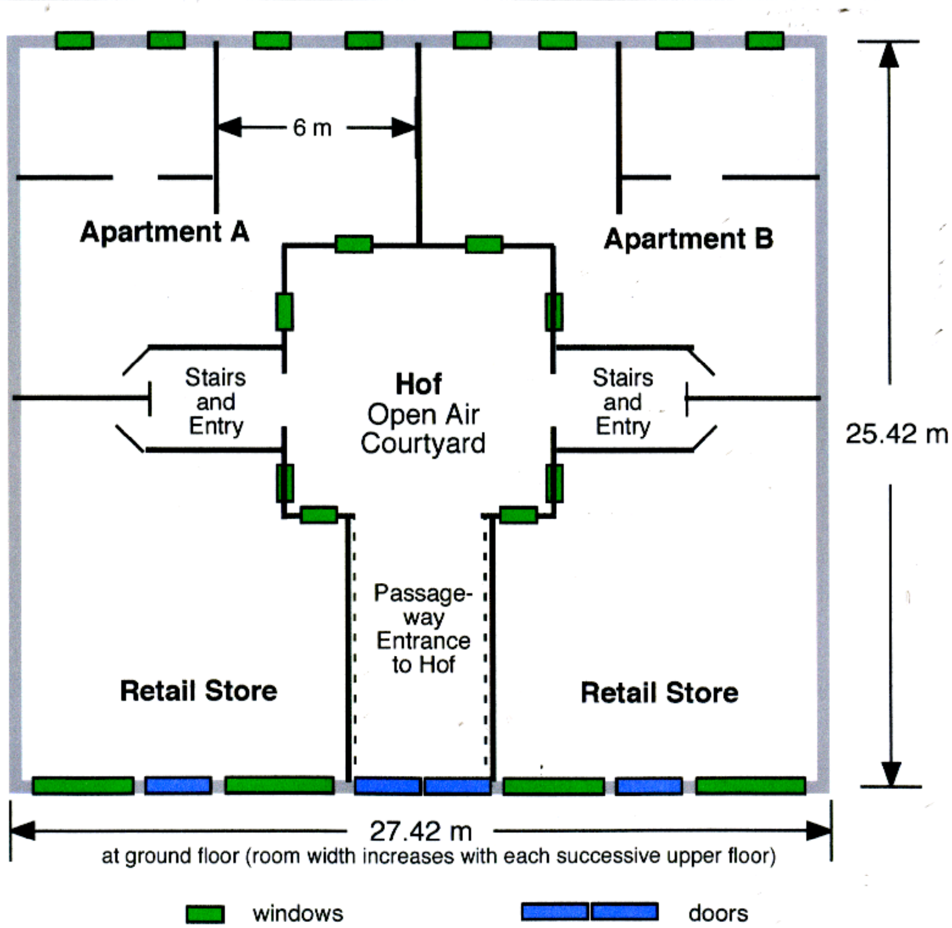


Figure 74. Mass 8-3-a floor plan.

Mass 8-3-b Floor Plan

Brick Apartment Building, Stores Below

Upper Story Floor Plan

Commentary

Hof style buildings form large areas of older Central and Eastern European cities. To make maximal use of surface space in the central city these buildings occupy all of their lots, with no setback from the street, and they abut like structures. The Hof is a "light well" from ground to building top (usually 5 stories) and allows venting to rooms facing the Hof. Stairways accessing the hof provide access to apartments on upper floors.

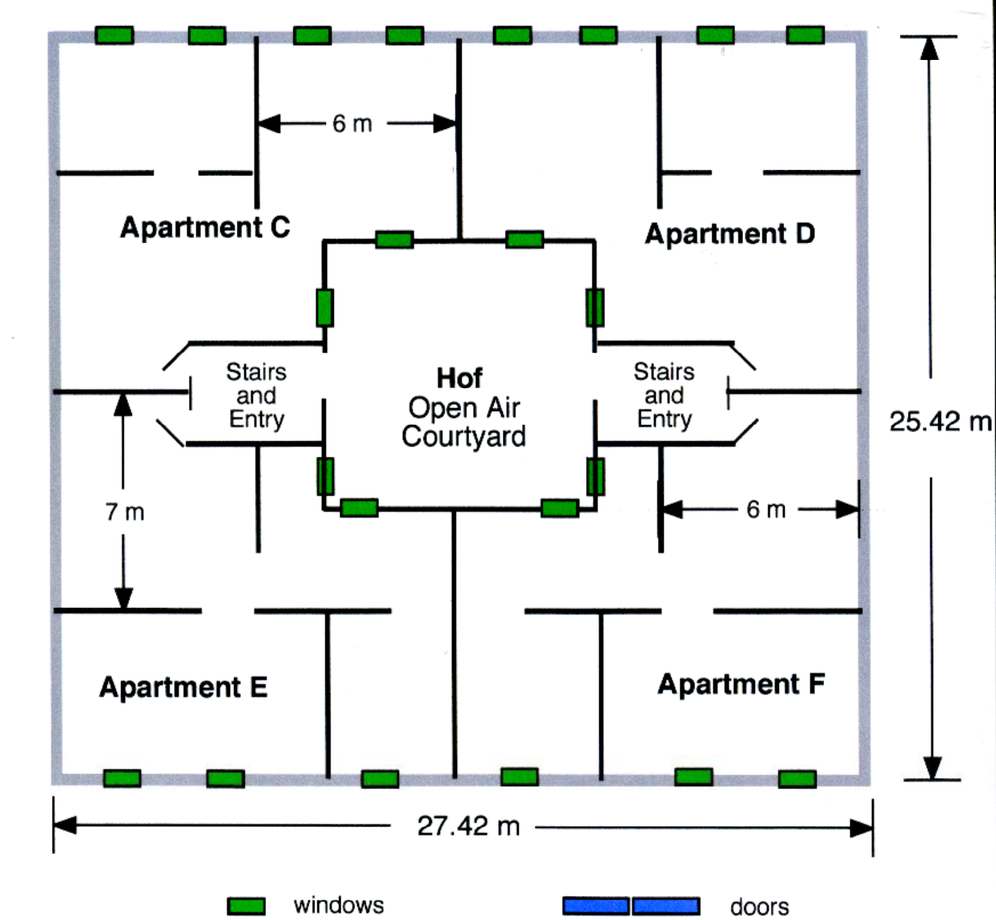


Figure 75. Mass 8-3-b floor plan.

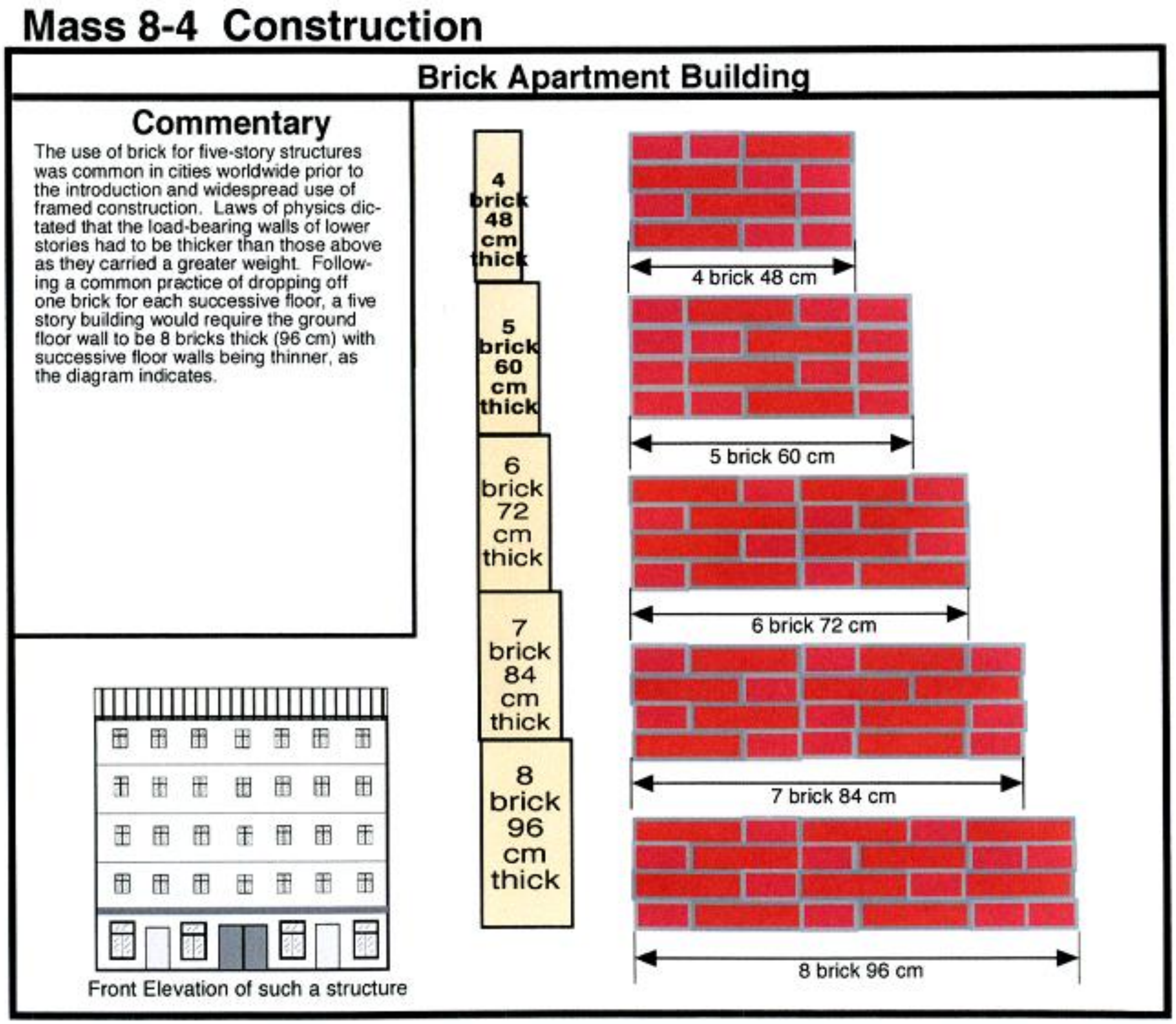


Figure 76. Mass 8-4 construction.

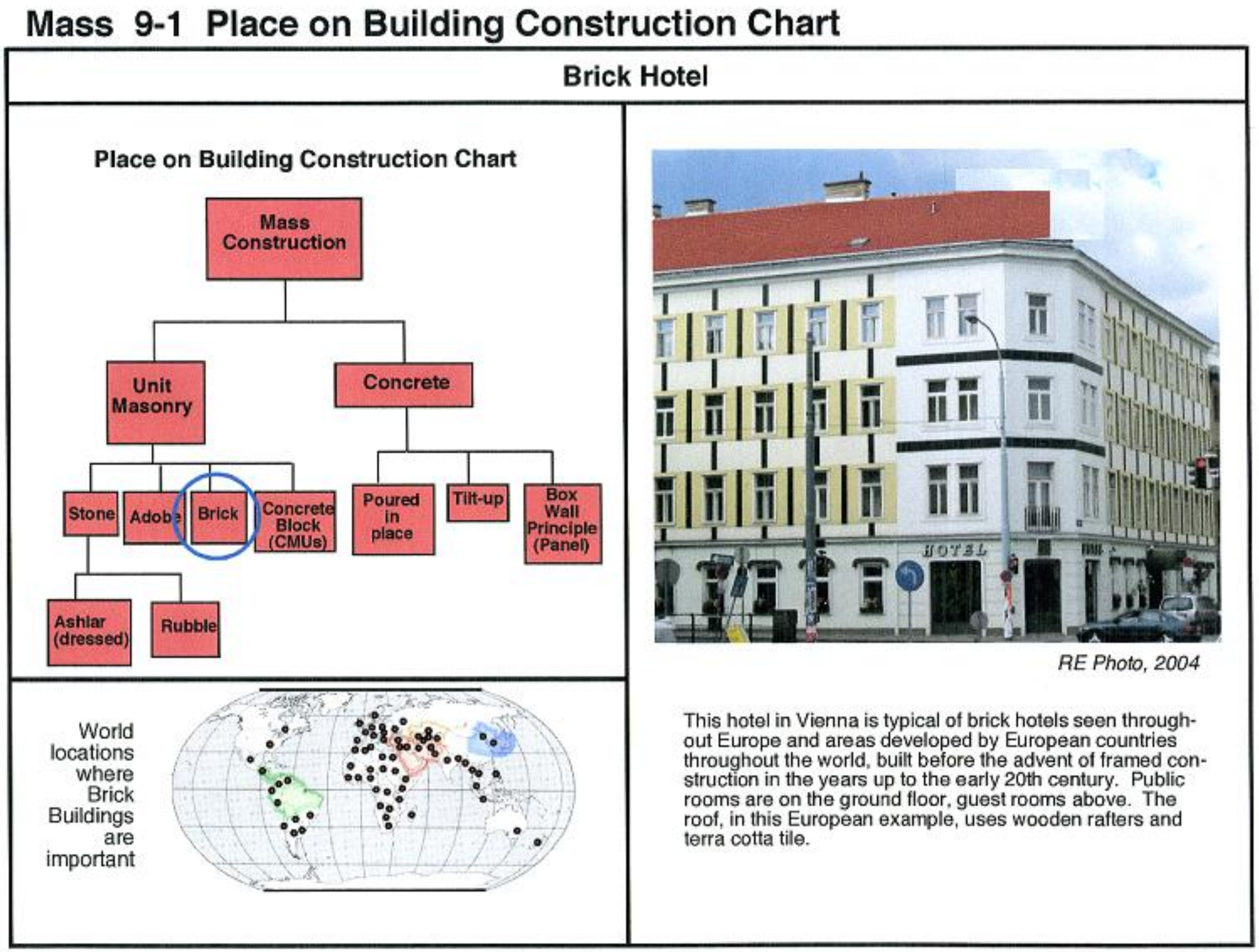
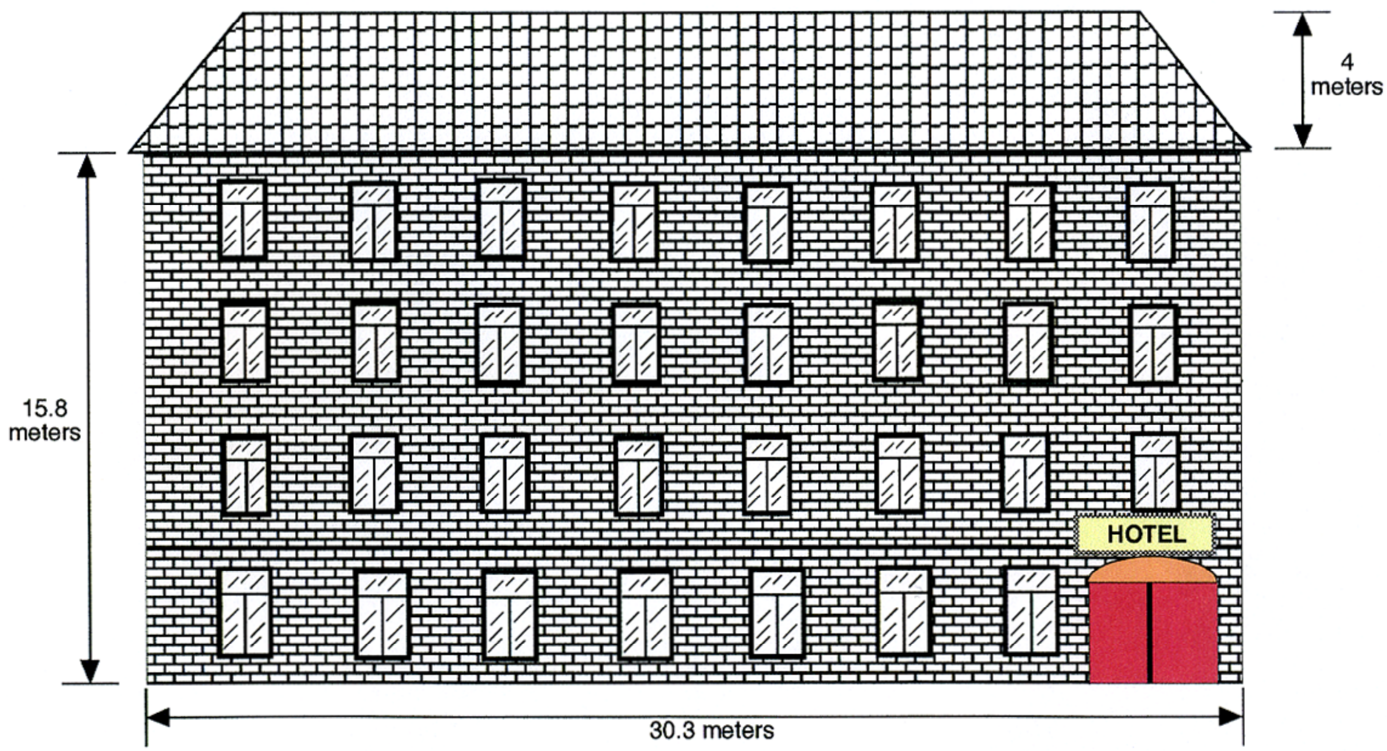


Figure 77. Mass 9-1 place on building construction chart.

Mass 9-2 Elevation

Brick Hotel

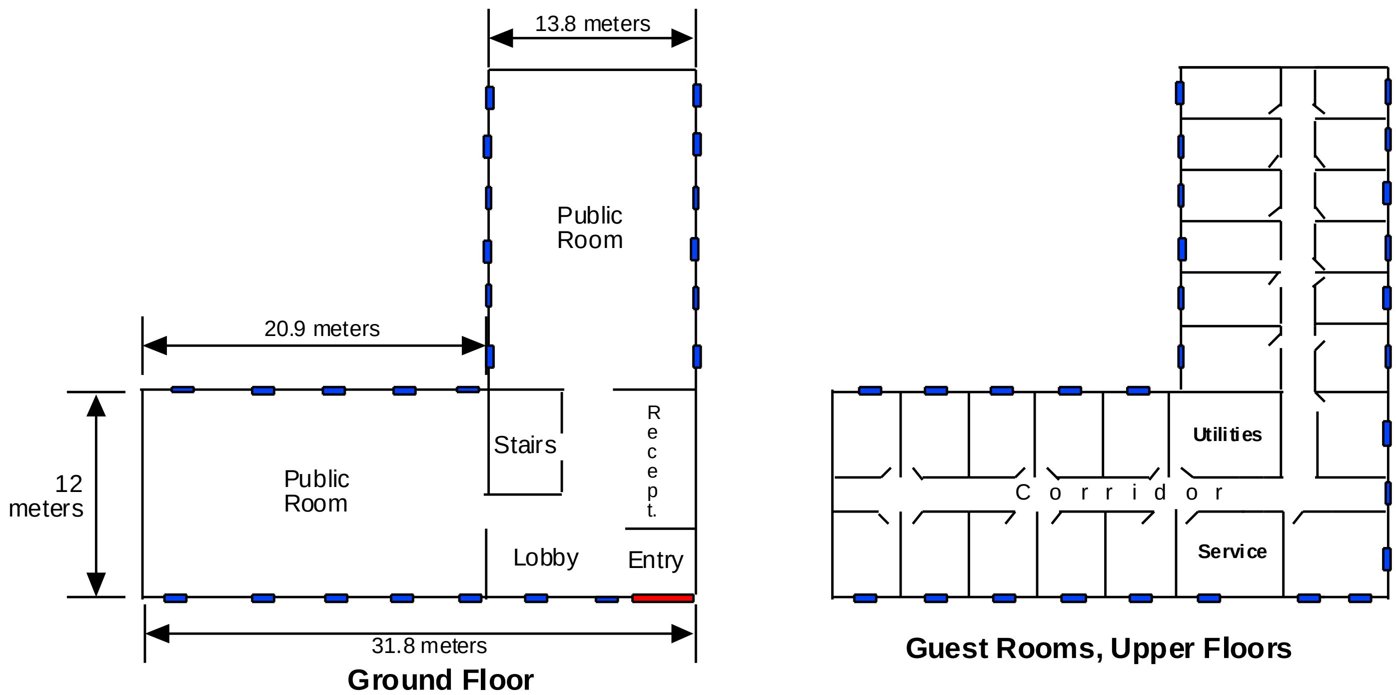


Commentary Exterior walls are all brick and load-bearing. Thickness varies from 8 bricks thick (96 cm) at the ground floor — atop the foundation — to 4 bricks (approximately 48 cm) for the top floor. Interior walls are also load-bearing but only 2 bricks thick (23 cm). Windows are larger for the public rooms on the ground floor, smaller for the guest rooms. The upper panel of each window is fixed, the lower parts swing outward from the center. All windows are vertically aligned, a common necessity of brick masonry structures.

Figure 78. Mass 9-2 elevation.

Mass 9-3-a Floor Plans

Brick Hotel



Commentary

The floor plans of brick hotels are similar to the framed construction hotels that followed in that in both cases, the functional requirements for guest rooms, public rooms, reception, service and utilities are the same. The guest room floors achieved efficiency with central corridors, and each guest room vented (in this case, the windows are European in style, and measure 1.5 x 2.5 meters.

Figure 79. Mass 9-3-a floor plans.

Mass 9-4 Construction: Wall and Window

Brick Apartment Building, Stores Below

Wall Thickness of Brick Building, Measured at Windows at Ground and Fifth Floor

Wall thickness at Ground Floor: 96 cm (8 bricks)

Window at Fourth Floor: 1.5 meters high, 1 meter wide

Wall thickness at Fourth Floor: 48 cm (4 bricks)

RE Photos

The photos demonstrate how tall, mass, brick buildings must have very thick walls on the ground floor to support all loads above and have walls that get progressively thinner with each story upward. The ground floor wall is almost a full meter thick, the fourth floor close to half a meter.

Figure 80. Mass 9-4 construction: wall and window.

Mass 10-1 Place on Building Construction Chart

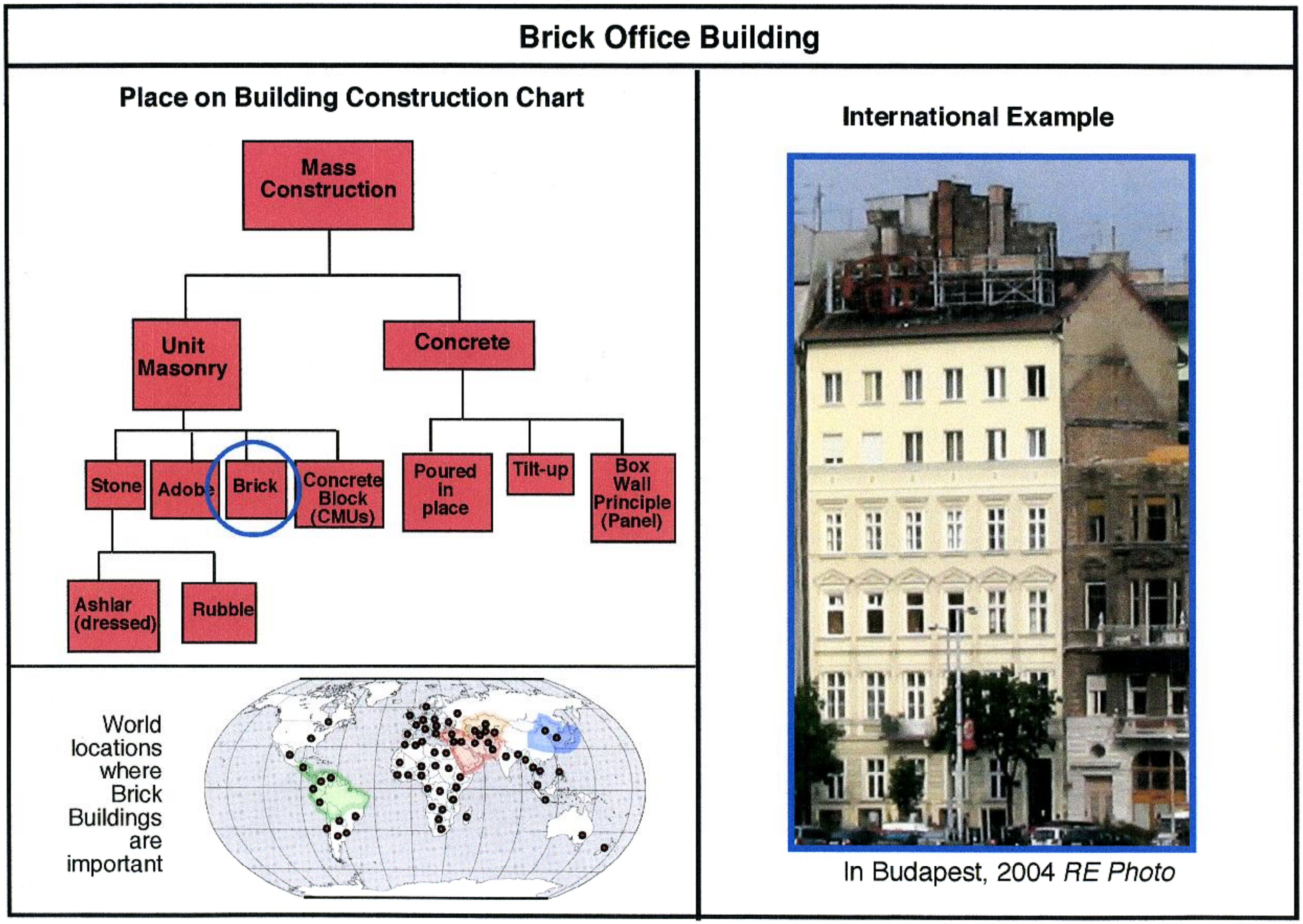


Figure 81. Mass 10-1 place on building construction chart.

Mass 10-2 Elevation

Brick Office Building

Front Elevation and Wall Thickness

Commentary

Brick buildings of this height (5 stories) are, by definition, at least 100 years old, considering that from about 1900 onward, buildings this high have employed a frame to support loads, although for a period of time their architectural details would appear from the exterior to be of masonry construction; in other words framed, heavy-clad. Because of the age of these brick buildings, the architectural style of the time favored grandness, expressed in ornamentation, and high ceilings in large rooms. The entry ways were also grand, and although somewhat worn still show an elegance not seen in modern buildings. Many buildings of this sort are extant in large European cities, especially the capitals. Many were also built in colonial cities. Note the thick brick walls required to support the great weights incurred.

Front Elevation

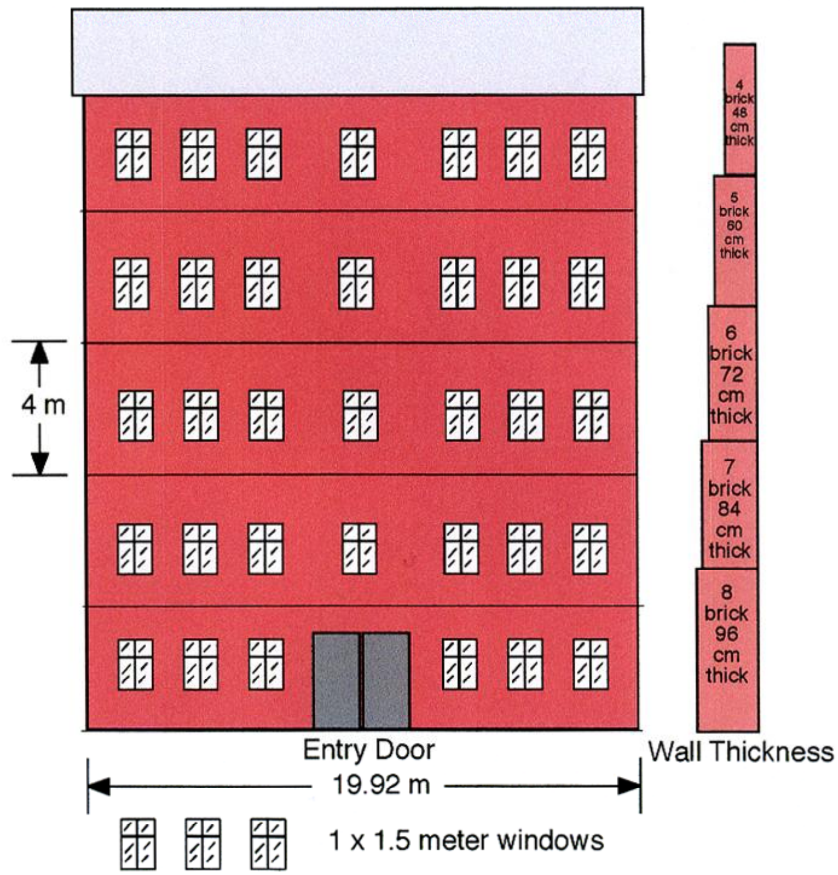


Figure 82. Mass 10-2 elevation.

Mass 10-3-a Floor Plan

Brick Office Building

Commentary

The floor plan for an office building followed the general design of the Hof (central light well, or courtyard) apartment building. Here, a tunnel-like ground floor entry accesses corridor, stair, and elevator module in the center of the building, thus providing access to offices around the periphery. This approach to access is significantly different than the modern one in which office access would be from a central corridor in a long, rectangular building. Lighting to the central module is artificial or enhanced with roof skylights. As is common in buildings of this age (a century or more), windows are long and narrow (usually about 1 x 1.5 meters) and have central openings. Many are doubled (each set opening independently), something easily achieved with the great thickness of the exterior walls. Interior walls are about 23 cm thick.

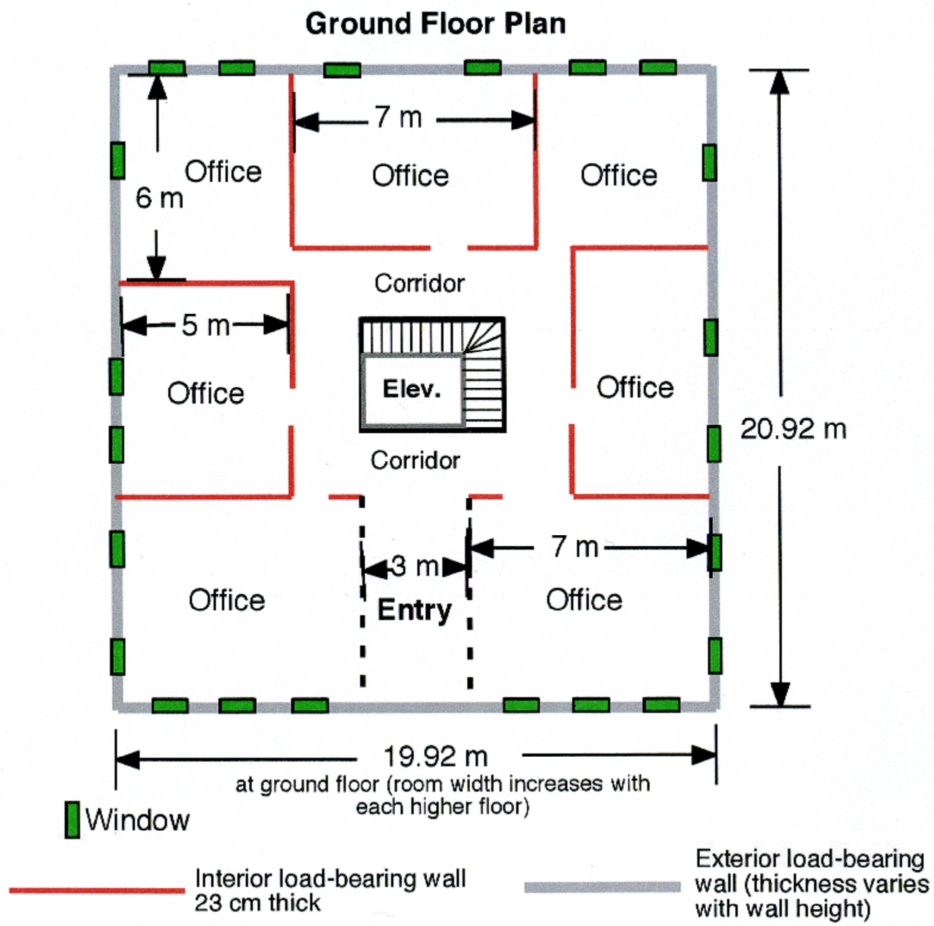


Figure 83. Mass 10-3-a floor plan.

Mass 10-3-b Floor Plan

Brick Office Building

Commentary

Offices on upper floors are accessed by elevator and stairs. Additional windows, above the entry way, are seen.

Upper Floor Plan

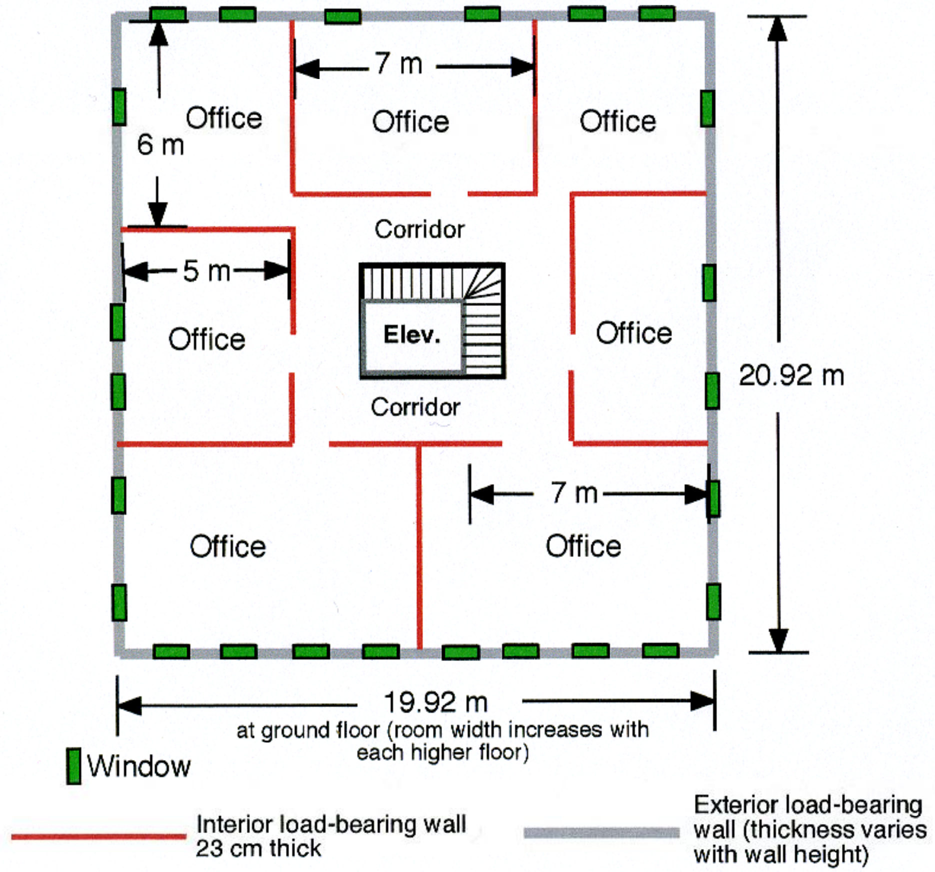
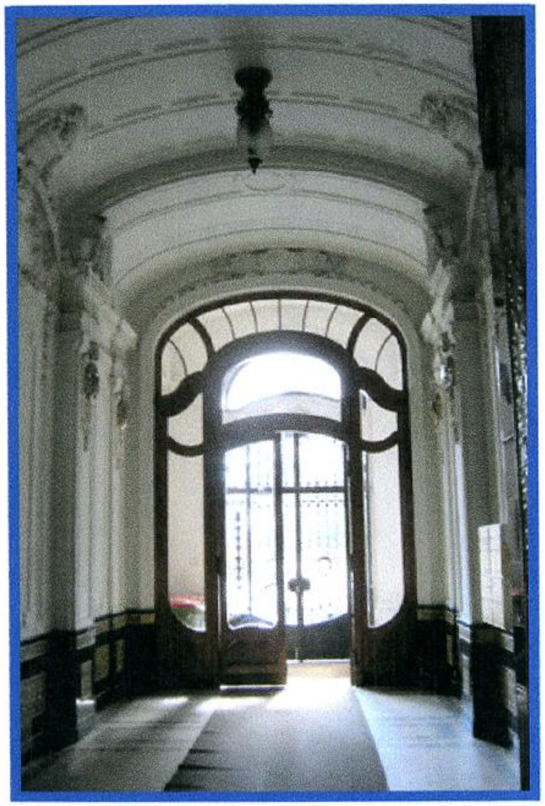


Figure 84. Mass 10-3-b floor plan.

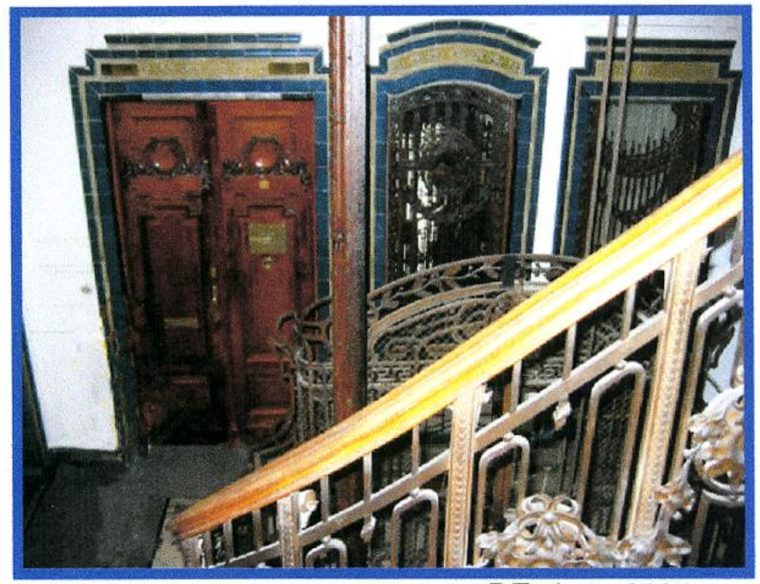
Mass 10-4 Construction, Interiors

Brick Office Building

Entry, Stairway and Elevator



RE photo 2004



RE photo 2004

Commentary

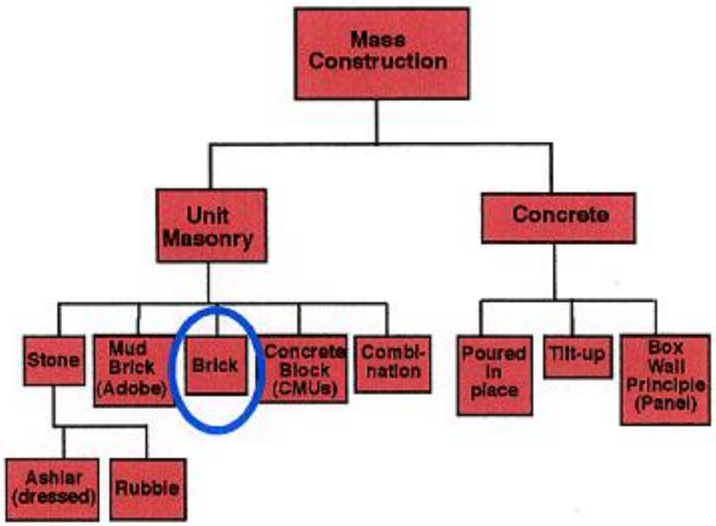
Design of these buildings (this one in Vienna) required a long entry way to the center of the building, the location of the elevator and stairs. Photo on the left, looking outward to the street entrance, demonstrates the commonly seen grand ornamentation. The photo above shows an elaborate door entrance to an office, the Victorian style elevator cage, and the decorated stair handrail.

Figure 85. Mass 10-4 construction, interiors.

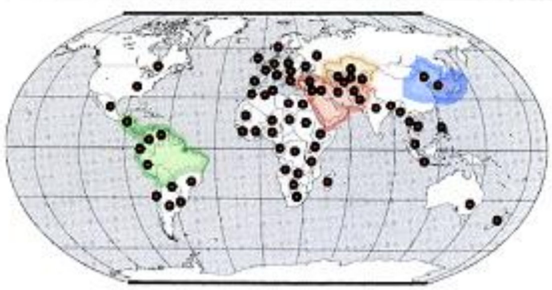
Mass 11-1 Place on Building Construction Chart

Brick Store

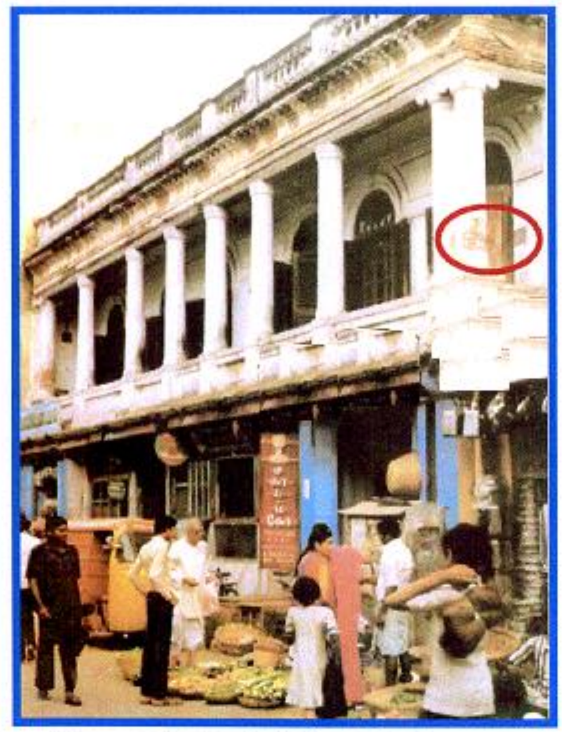
Place on Building Construction Chart



World locations where Brick Buildings are important



International Example



An elaborate brick building in Chennai (Madras), India with commercial use on the ground floor, residential above. Note exposed brick on the upper right corner. *RE photo.*

Figure 86. Mass 11-1 place on building construction chart.

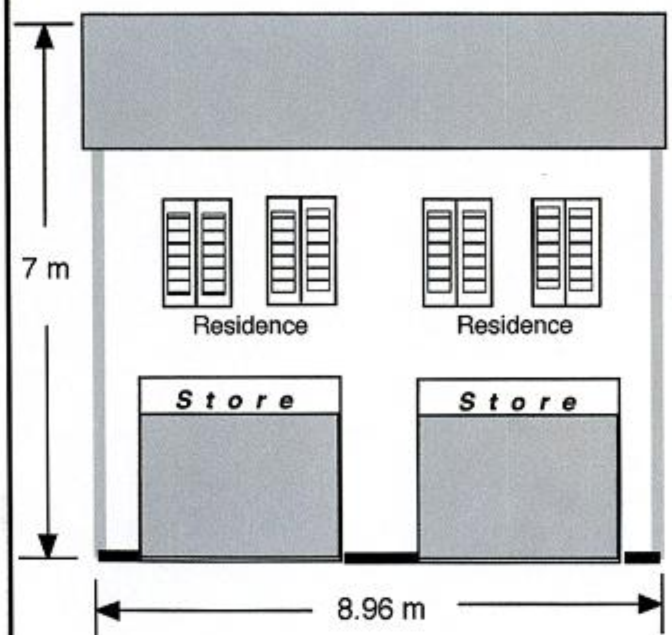
Mass 11-2 Elevation

Brick Store

Commentary

Narrow store frontages are seen throughout the world in crowded urban areas, and especially along arterial streets. Rent is charged by "the front foot" reflecting its high exposure value. The residences above the store are normally occupied by the store owner and his family.

Front Elevation



RE photo: Bangkok 2004

Figure 87. Mass 11-2 elevation.

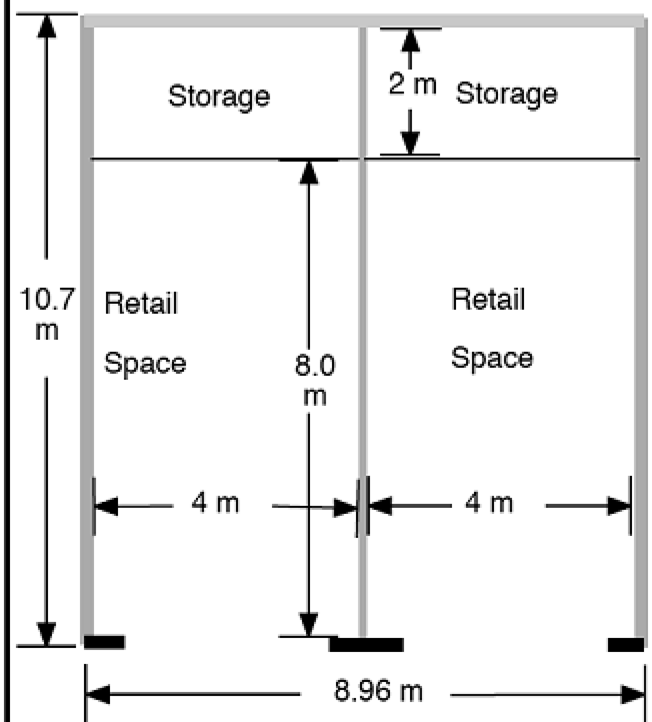
Mass 11-3-a Floor Plan

Brick Store

Commentary

A very common occurrence in Third World cities is the narrow (and small footprint) retail store, located on heavily trafficked streets. Floor space is narrow, but wide enough to be seen by the “passing trade” and thus making maximal use of high-rent street frontage. The floor is deep, the customer once inside is served on “cheaper” land. Storage space is at the rear; store owners may reside in this rear space. In the photo example, shop keepers probably live in the residential quarters above the stores.

Store Floor Plan



Separation wall between stores is also load-bearing but only double brick (23 cm)

RE photo: Bangkok 2004

Side wall 36 cm thick (counting mortar) triple brick. Wall projects through attic and roof (see photo) to form a fire wall

Figure 88. Mass 11-3-a floor plan.

Mass 11-4 Construction

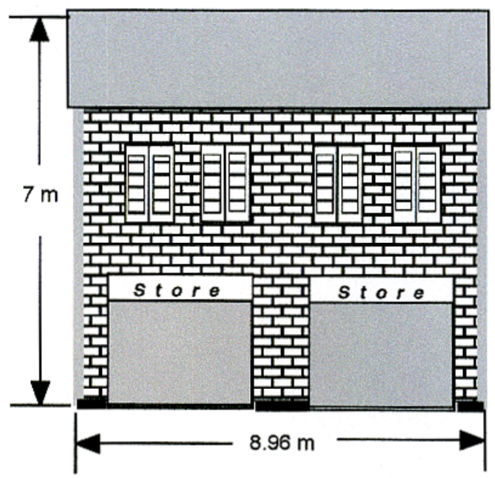
Triple Brick Store

Construction: Triple Brick load-bearing Walls

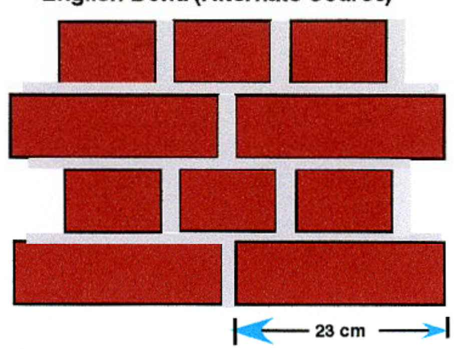
Commentary

This building employs the very common method of forming a load-bearing brick wall, namely use of Triple Brick, sufficient in strength for a single story or two story building. It is formed of one stretcher and one header. This arrangement manifests itself in the English bond (alternate courses of headers and stretchers) illustrated here. This combination of bricks and intervening mortar yields a total wall thickness of 36 cm.

While well mortared brick can withstand the elements, the common practice is to cover the brick with stucco.



English Bond (Alternate Course)



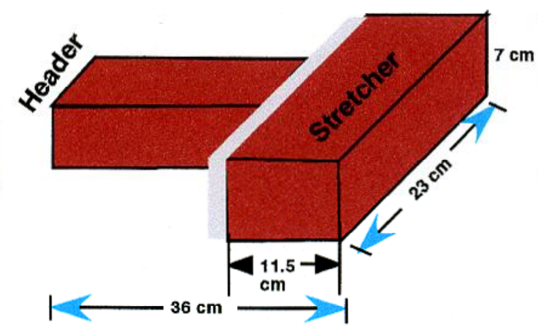
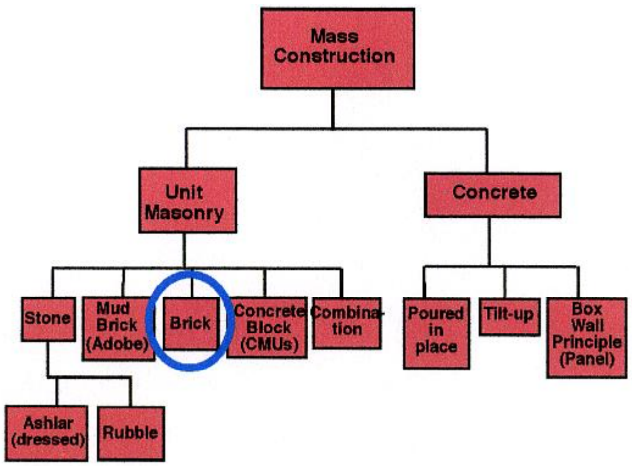


Figure 89. Mass 11-4 construction.

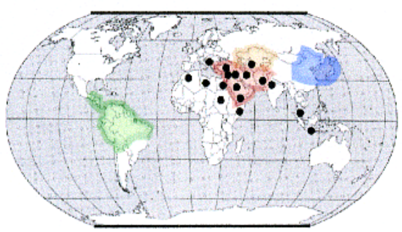
Mass 12-1 Place on Building Construction Chart

Brick Mosque

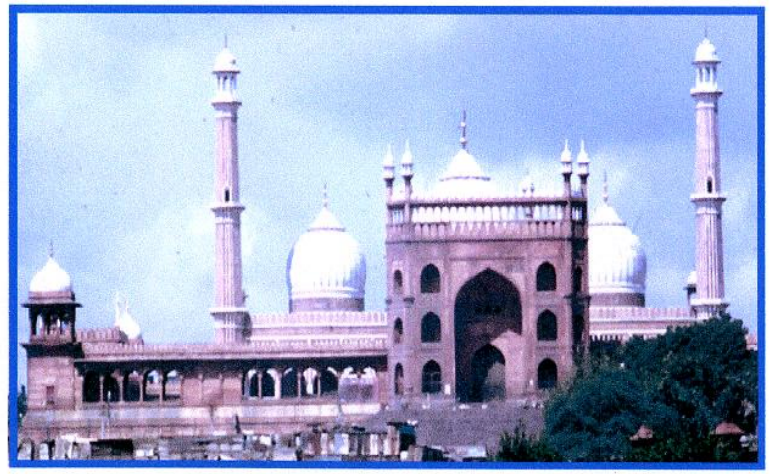
Place on Building Construction Chart



World locations where mosques are important



International Example



RE photo.

A mosque in Delhi, shows the elaborate architecture of a large mosque, used for congregational services on Fridays. This particular structure is made of the red sandstone, prominent in the Red Fort, nearby. The building has the domes, the arches, massive gateway, and the minarets (as seen in the drawings).

Figure 90. Mass 12-1 place on building construction chart.

Mass 12-2 Elevation and Floor Plan

Brick Mosque

Commentary

Representative features of a mosque are given here. While actual design varies from place to place in the Muslim world, several features are common and aggregated here. Reflecting the religion's four levels of prayer is the symbolic use of four minarets, one at each corner, the four corners and the rectangular shape itself, and the four entry gates. The structure has two domes, one the larger and dominant. Of the four prayer levels (individual, congregation, a town's population, and the entire Muslim world) the example here is that of a "Friday Mosque," used for a weekly service for a congregation and served by the Open Court.

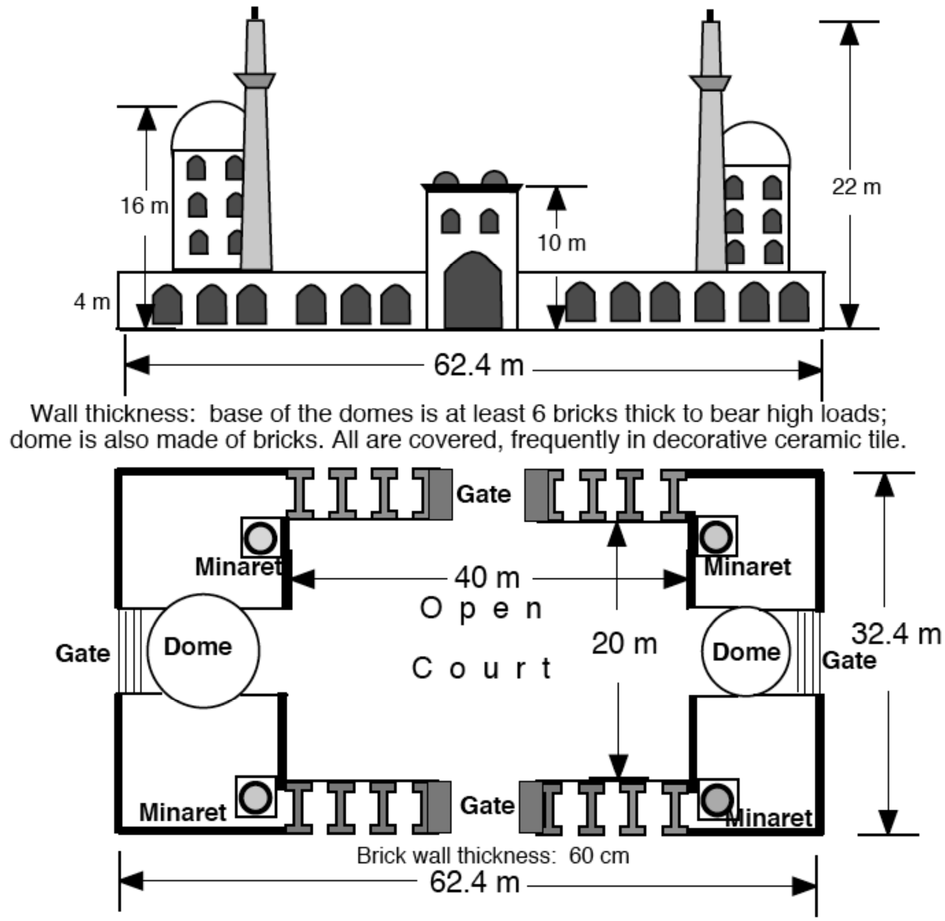
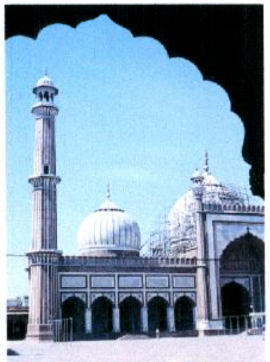


Figure 91. Mass 12-2 elevation and floor plan.

Mass 12-3-a Floor Plan

Mosque



RE photo

A mosque in Delhi, India with its domes and Minaret

Commentary

This example mosque is presumed to be in Tehran, Iran. Its *Mihrab* is oriented in a south-westerly direction to face Mecca; orientation is based on a global great circle.

The courtyard is immediately to the inside of the *Iwan* followed by the prayer hall. Prayers are led by the Imam standing in the *Minbar* (always placed to the right of the *Mihrab*). The *Mihrab* commonly has elaborate decoration.

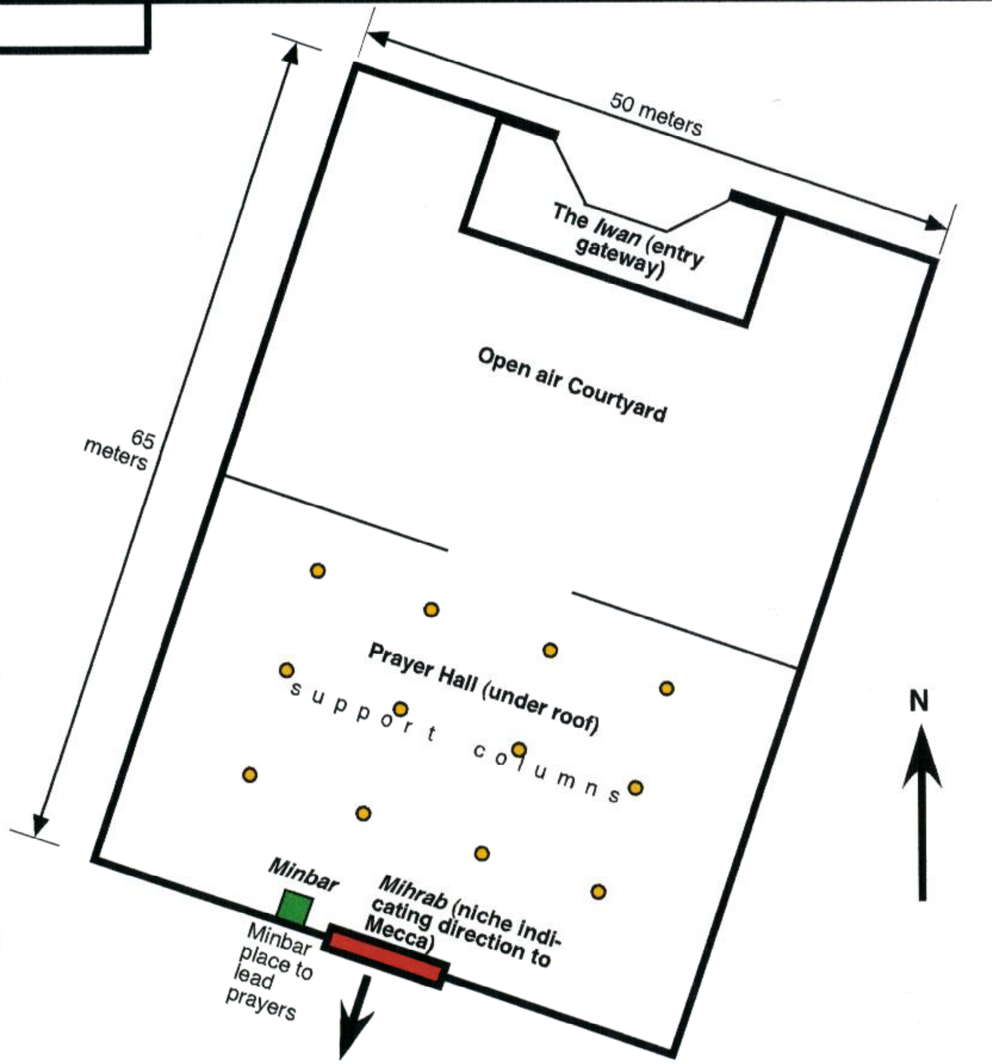


Figure 92. Mass 12-3-a floor plan.

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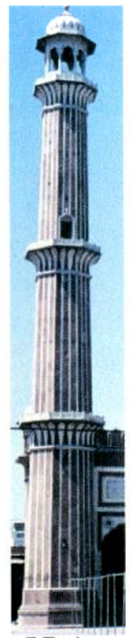
Mass 12-4 Construction

Mosque

Commentary

Considering that Islam is found in many diverse regions of the world, a variety of construction forms occur. Examples of construction here, common mainly to the Middle East, Central and Southwest Asia, employ brick and stone construction.

Selected are features basic to all mosques, i.e., the entry gateway (the *Iwan*); minarets; domes; interior columns to support the roof of the enclosed prayer room. Examples of materials and dimensions are intended to represent an average. Many variations occur due to local physical situations and to history; recently built mosques will often employ modern building techniques and materials, such as reinforced concrete.



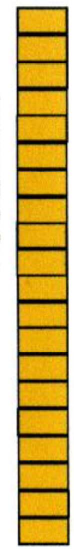
RE photo

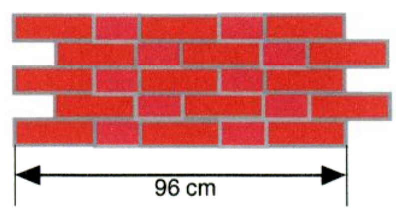
A minaret with its typical tapered form and the platforms for the call to prayer. Stairways to the top are internal.

RE photo

Domes are complex structures. They can be made of brick, stone, wood, or reinforced concrete.

Interior columns often use stacked stones. Brick and concrete are also used.





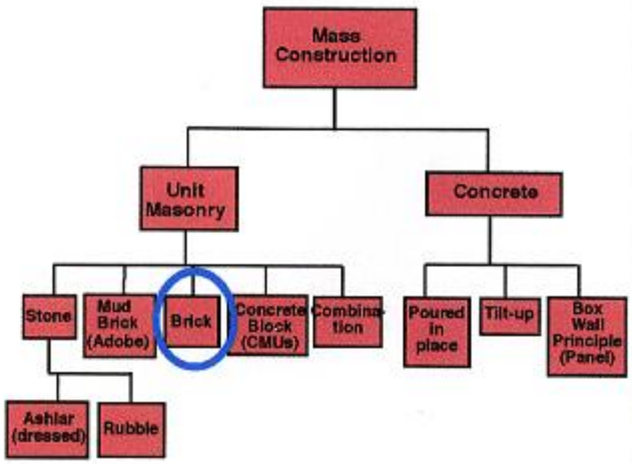
Cross-section of part of the exterior wall, 96 cm thick. The complex Flemish bond, illustrated, is commonly used in mosque construction.

Figure 93. Mass 12-4 construction.

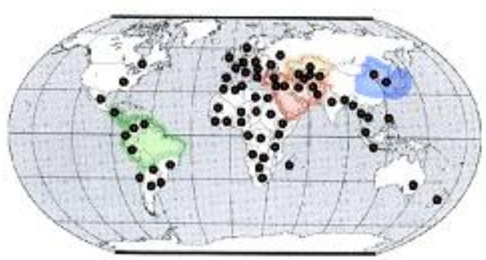
Mass 13-1 Place on Building Construction Chart

Brick Industrial/Storage Building

Place on Building Construction Chart



World locations where Brick Buildings are important



International Example

RE photo.

Prior to the advent of economical construction with reinforced concrete posts and beams with CMU, brick, or terra cotta infill, those activities needing large enclosed areas for industry or storage used traditional brick construction (triple brick, in this example case). This building is being used by a cooperative engaged in the production of "Sherry" (so derived from the name of the province of Jerez, in Spain). The arched windows at the front of the building are a good indication of its brick nature, the arches replacing load-carrying support when window openings were made.

Figure 94. Mass 13-1 place on building construction chart.

Mass 13-2 Elevation

Brick Industrial/Storage Building

Commentary

This simple brick structure has in common with its more advanced counterparts a large truck access door, window venting, and a person access door. The pitched roof is common.

Front Elevation

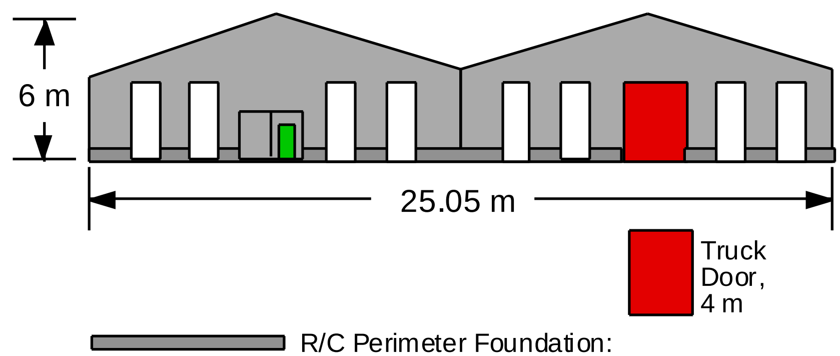


Figure 95. Mass 13-2 elevation.

Mass 13-3-a Floor Plan

Brick Industrial/Storage Building

Commentary

This simple brick building represents many of its type in use worldwide for such elemental tasks as farm storage for equipment, fodder, and animals and simple support for construction activities for equipment and material. Load-bearing brick wall construction for the structure is the standard triple brick reaching a thickness throughout of 36 cm.

Floor Plan

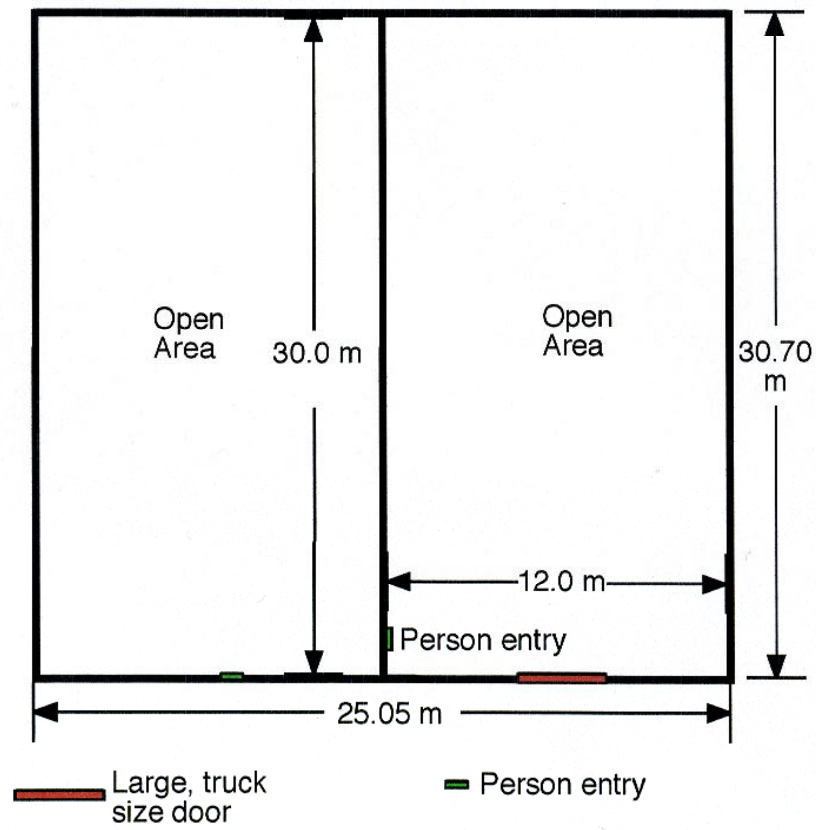


Figure 96. Mass 13-3-a floor plan.

Mass 13-4 Construction

Triple Brick Industrial/Storage Building

Construction: Triple Brick load-bearing Walls

Commentary

This building employs the very common method of forming a load-bearing brick wall, namely use of Triple Brick, sufficient in strength for a single story or two story building. It is formed of one stretcher and one header. This arrangement manifests itself in the English bond (alternate courses of headers and stretchers) illustrated here. This combination of bricks and intervening mortar yields a total wall thickness of 36 cm.

While well mortared brick can withstand the elements, the common practice is to cover the brick with stucco.

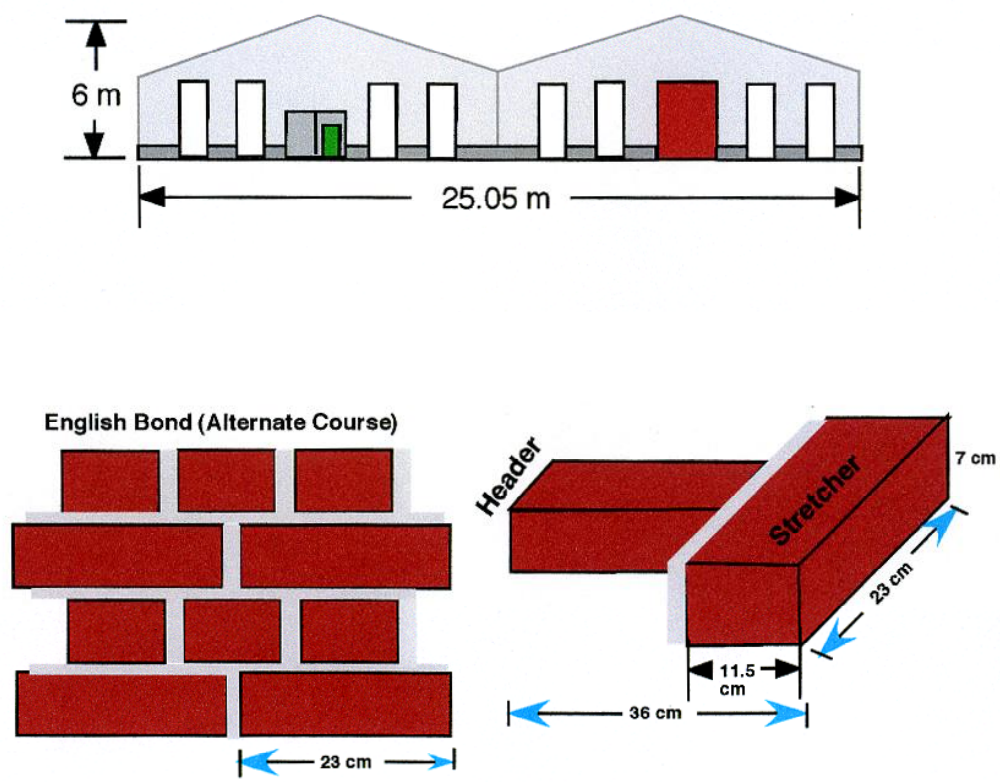
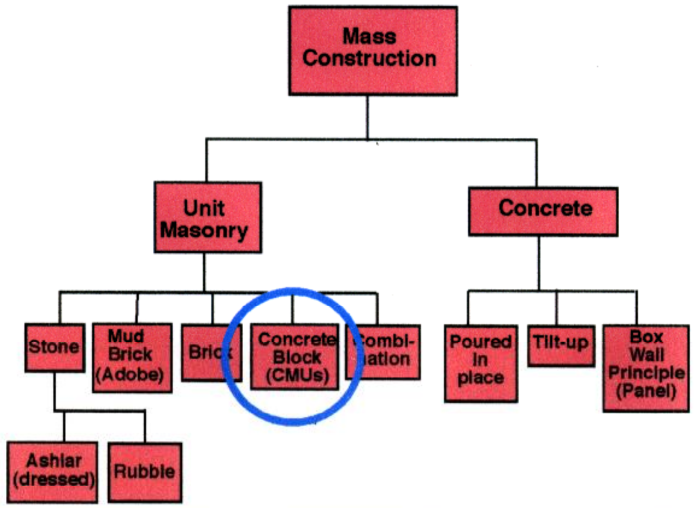


Figure 97. Mass 13-4 construction.

Mass 14-1 Place on Building Construction Chart

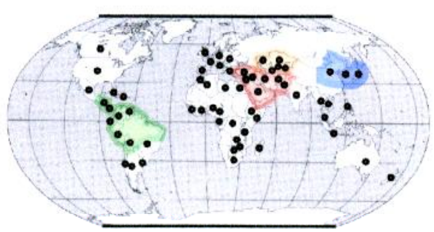
CMU One and a Half Story House

Place on Building Construction Chart



The photographs show (upper) a CMU building under construction (in Costa Rica) with rebar placed through the cavities of the CMU blocks (blocks are 40 x 20 x 20 cm). The lower photo shows a wall with a concrete beam across the top sealing the rebar.

World locations where CMU Buildings are Important



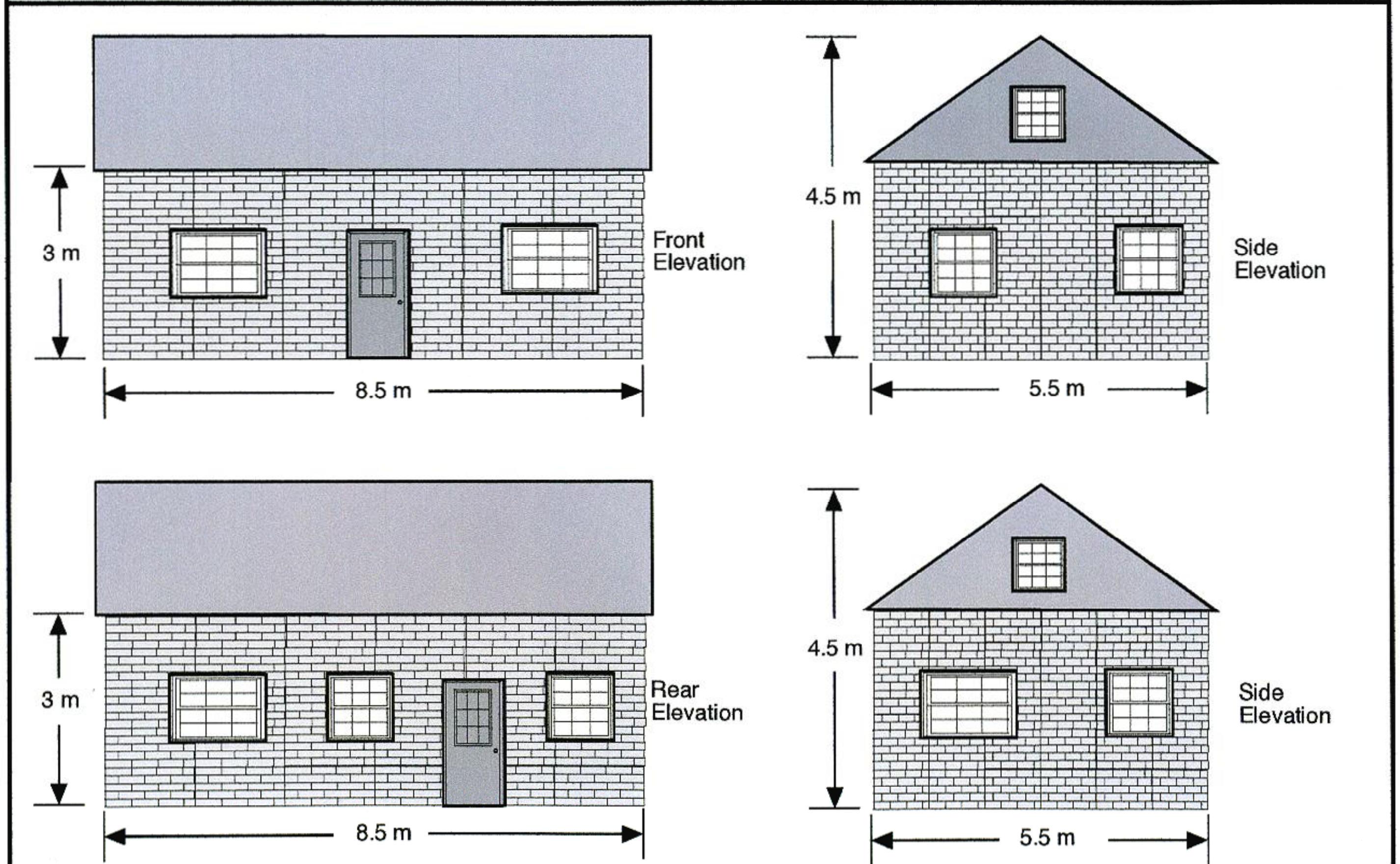
International Example

RE photos.

Figure 98. Mass 14-1 place on building construction chart.

Mass 14-2 Elevations

CMU House



Commentary: Proportions of windows and doors to wall surface space is, for this example, nearly the same as the aggregated figures cited earlier in the text. The proportion of window to wall on the front elevation is 12.7%, 14.2% for the rear wall, 12.4% for the side wall (upper right) and 14.7 % for the side wall (lower right). The aggregate figure for all mass construction houses is 11.1% windows to wall. Combined figures (windows and doors) are also similar; 12.4% for this example, 15.5% for the aggregate.

Figure 99. Mass 14-2 elevations.

Mass 14-3-a Floor Plan

CMU One and a Half Story House

Commentary

The small area house (64 square meters) shown here is of the sort found in low economic level areas where CMU construction is used instead of r/c framed with infill that is used for larger houses. Accordingly, room sizes are small but probably appear to be luxurious by standards of village-living or in the shanty towns that have sprouted at the edge of many third world cities. Construction is sound, however, using load-bearing thick walls and load-bearing thinner interior walls. Windows and doors use standard metric sizes, e.g., 1 meter doors and some windows.

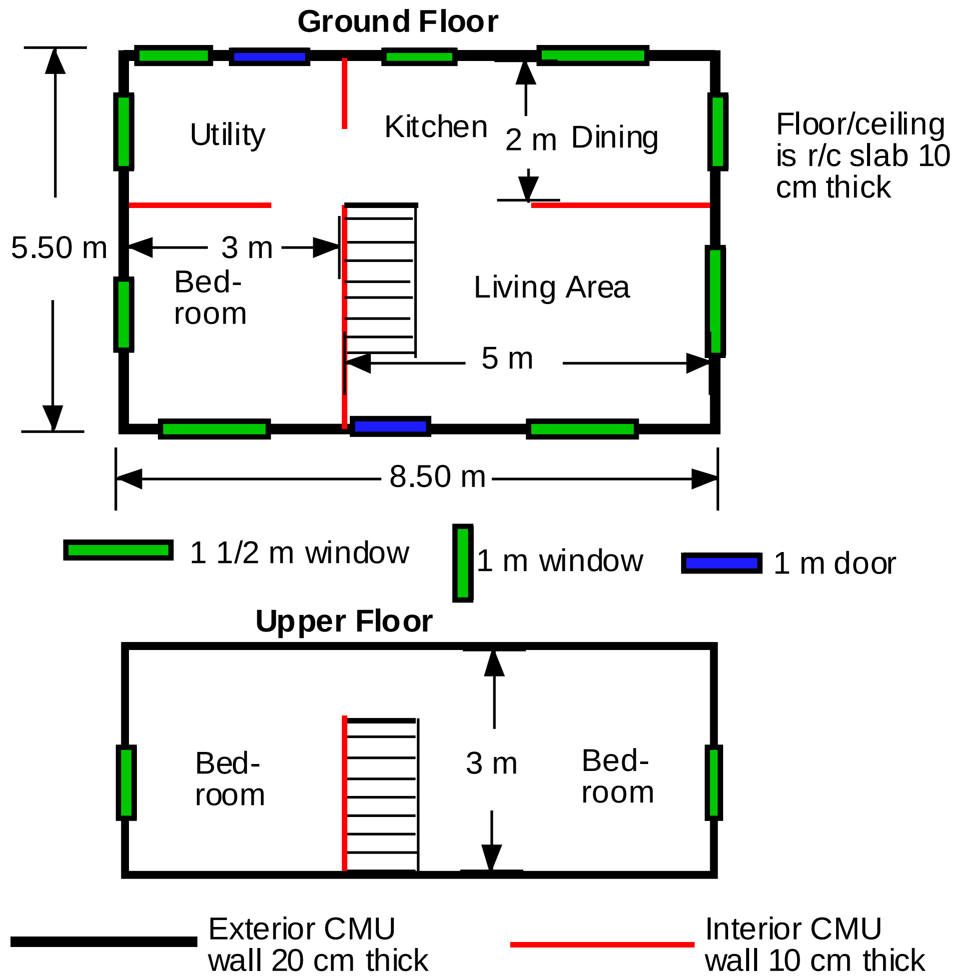


Figure 100. Mass 14-3-a floor plan.

Mass 14-4-a Construction

CMU One and a Half Story House

Reinforced CMU Construction

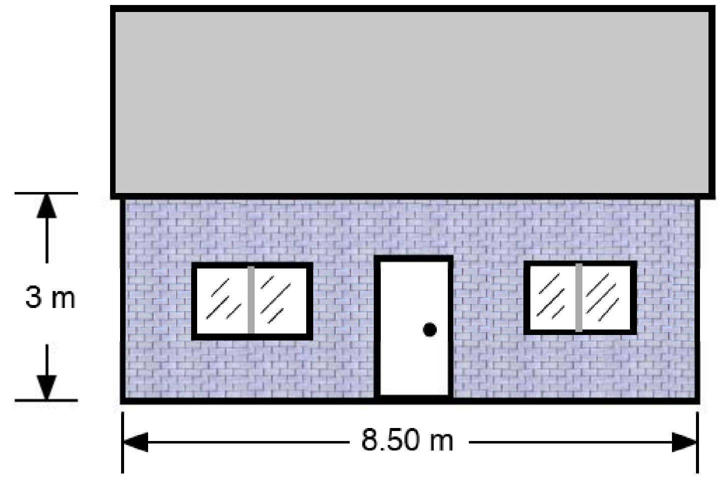
Commentary

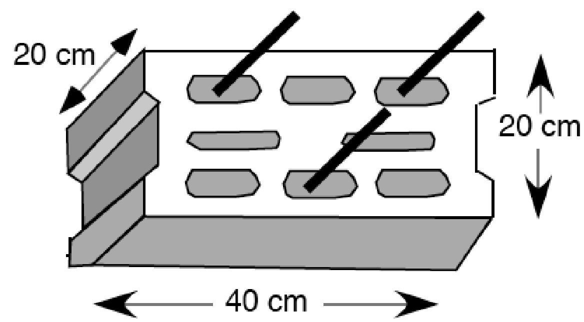
This front elevation of this mass construction house employs a CMU of a common international size (larger than the common US size). Reinforcement is achieved with grouted rebars placed in some of the cavities in the hollow CMU block. Specific dimensions are seen at lower right.

Block walls are commonly covered with stucco to provide weather protection.

This front elevation shows the windows for the living room on the left and the dining room on the right, with the front entry door in the middle.

Front Elevation





Concrete Masonry Unit (CMU) with cavities and 3 example rebars. Cavities with rebars are filled with grout.

Figure 101. Mass 14-4-a construction.

Mass 14-4-b Constructon

CMU One and a Half Story House

Two cavity CMU blocks have a single rebar in each cavity. Grout has been poured and tamped as each course is added. Maximum construction here meets earthquake code in California. *RE photo.*

Another method of reinforcement uses two rebars placed in alternate cavities.

The same wall as above showing double rebar at the wall's corner. *RE photo.*

Commentary

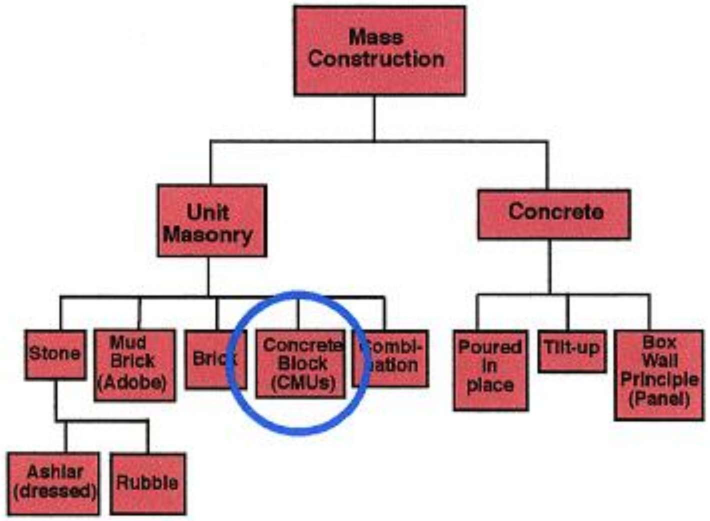
Use of reinforcement and its density and use of grout vary from no reinforcement in simple Third World buildings and simple structures in the First World to maximum reinforcement in well capitalized construction in advanced areas, especially where code dictates and structures are built to last.

Figure 102. Mass 14-4-b construction.

Mass 15-1 Place on Building Construction Chart

CMU Single floor store

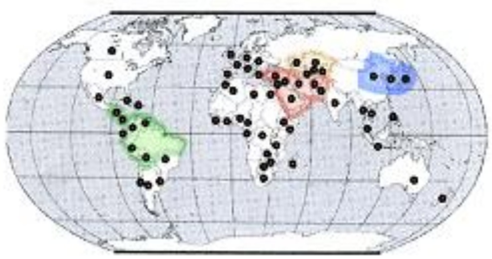
Place on Building Construction Chart



International Example

RE photo.

World locations where CMU Buildings are Important

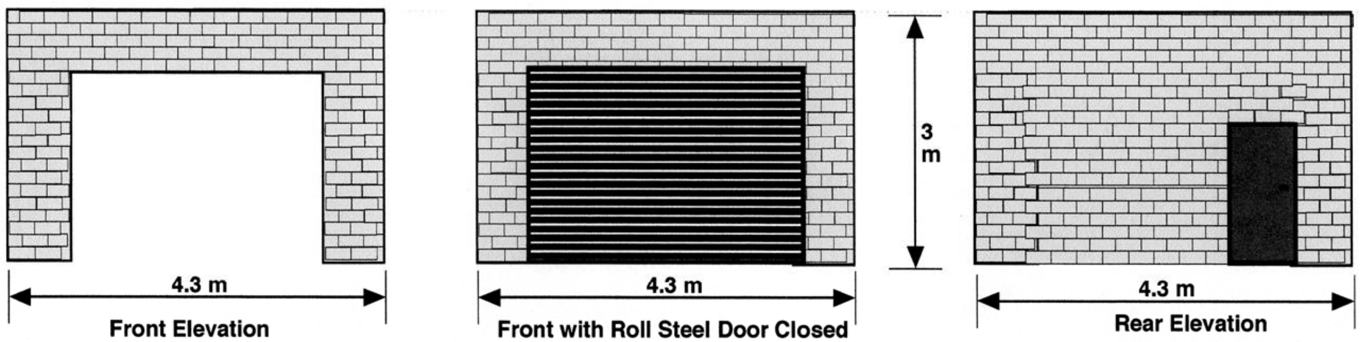


This single story CMU store, located along a thoroughfare near Colombo, Sri Lanka, is typical of small, cheaply constructed buildings in Third World countries. Most of the store front is devoted to display space for offered merchandise. Sign is dual language, English and Sinhalese.

Figure 103. Mass 15-1 place on building construction chart.

Mass 15-2 Elevations

CMU Store



Commentary

Small, crudely constructed buildings of this sort have the common characteristics of large openings at the front (plate glass is seen in some), sealed in off-business hours by a steel door that rolls down to floor level. The rear has an entry for the shop owner, sides are blank, often abutting shops of the same type. CMU blocks measure 20 x 40 x 20 cm.

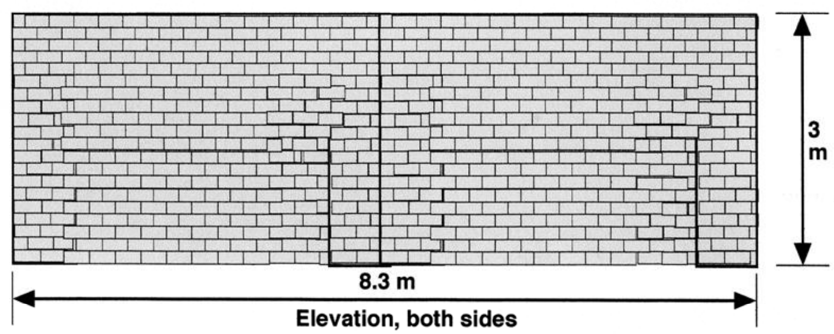


Figure 104. Mass 15-2 elevations.

Mass 15-3-a Floor Plan

Single Floor CMU Store

Commentary

Stores of this type in Third World countries use the simplest of construction method (unreinforced CMU blocks) and the simplest of floor plans. Shop owners are not capitalized well enough to build more substantial structures. Emphasis is placed on the display and sale of merchandise, with only a small area devoted to storage of limited inventory.

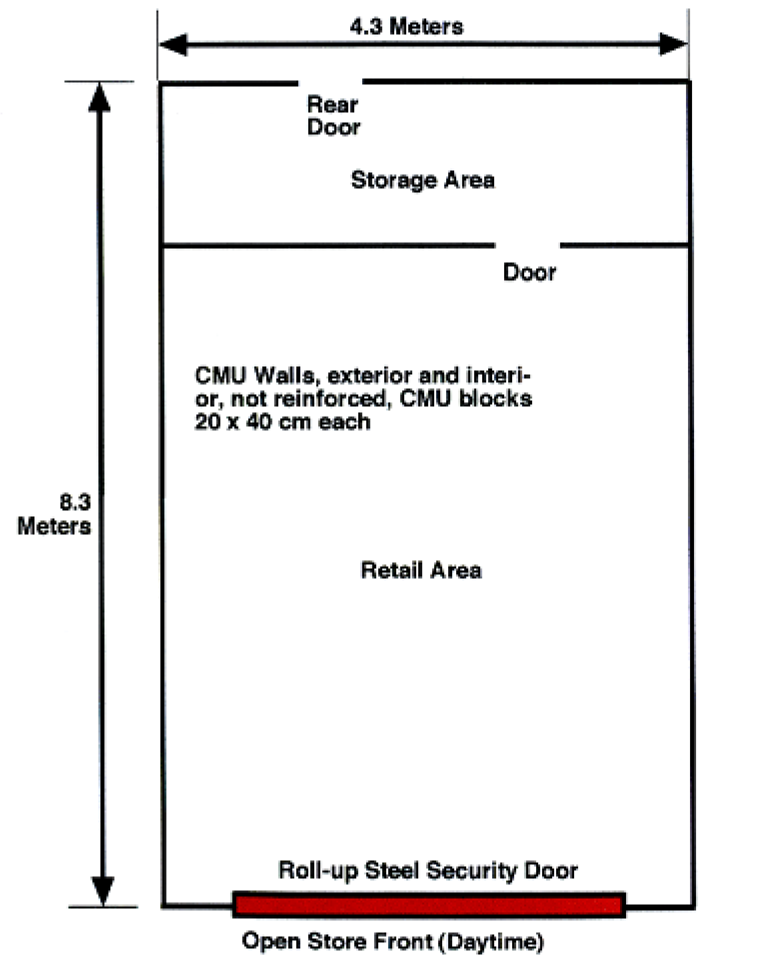
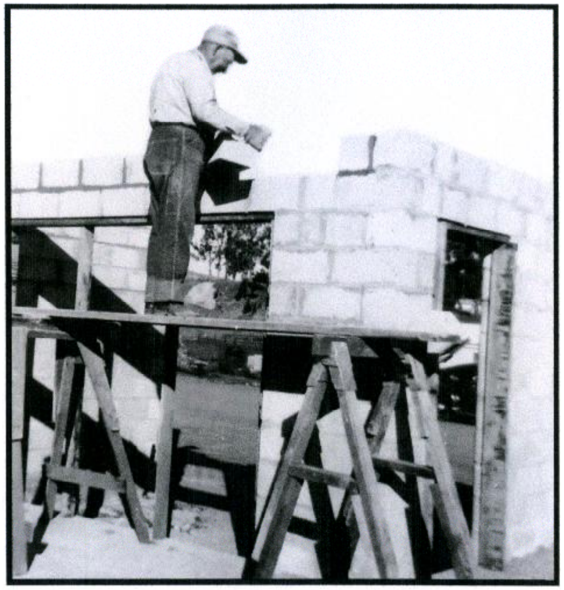


Figure 105. Mass 15-3-a floor plan.

Mass 15-4 Construction

CMU Single floor Store



Top row CMUs being laid in construction of a single story building. No rebar has been used in its construction. This form of construction is common for single story structures in Third World countries.

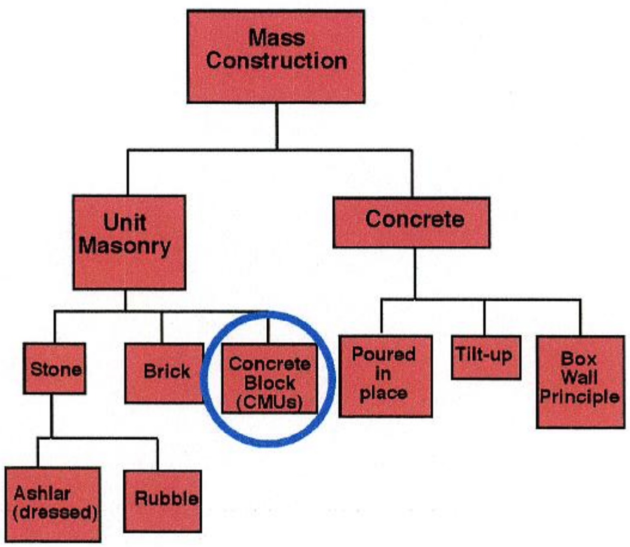
CMU blocks in Tel Aviv, Israel. Two styles of cavities are seen. Blocks measure 40 x 20 x 20 cm.

Figure 106. Mass 15-4 construction.

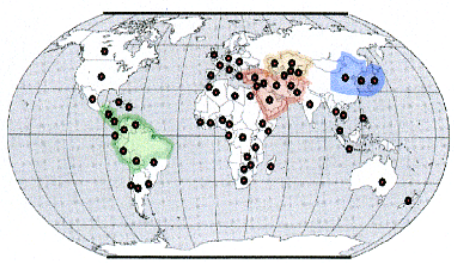
Mass 16-1 Place on Building Construction Chart

CMU Industrial/Storage Building

Place on Building Construction Chart



World locations where CMU Buildings are Important



Roof, supported by trusses, commonly made of some light material, e.g., plywood, lumber, or corrugated steel, and covered with standard roofing material, e.g., rolled asphalt roofing.

Commentary

This building is given the above classification because, most of the load is borne by the outer reinforced CMU walls. Part of the roof load, however, is supported by trusses, and these by hollow steel columns.

Figure 107. Mass 16-1 place on building construction chart.

Mass 16-2 Elevation

CMU Industrial/Storage Building

Commentary

CMU blocks are exposed on all elevations of this building (with vented front and rear shown here).

Large roll-up doors in the rear serve the manufacturing function.

A front entrance and office windows are on the front elevation.

Building is 8 meters tall to accommodate doors and enable truck entrance.

Elevations

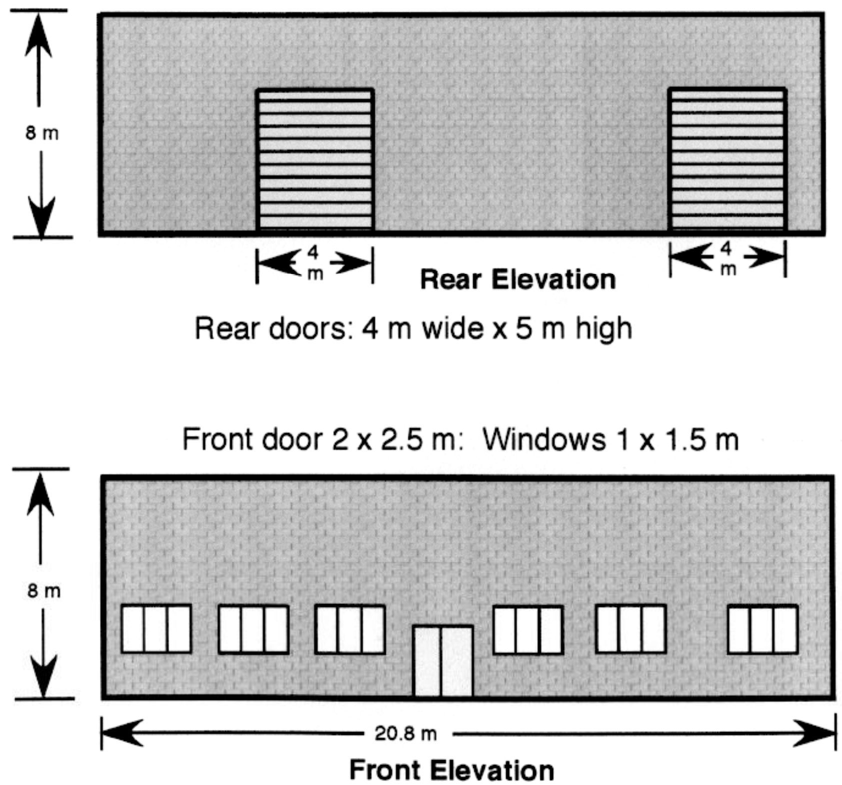


Figure 108. Mass 16-2 elevation.

Mass 16-3-a Floor Plans

CMU Industrial/Storage Building

Commentary

Typical functions of a manufacturing process occupy appropriately sized spaces. Flow is from manufacturing, to assembly, to packing, and then to storage and shipping. Large rear doors accommodate trucks and fork lifts. Doors between the functions are large. Offices, requisite to the process, are in front.

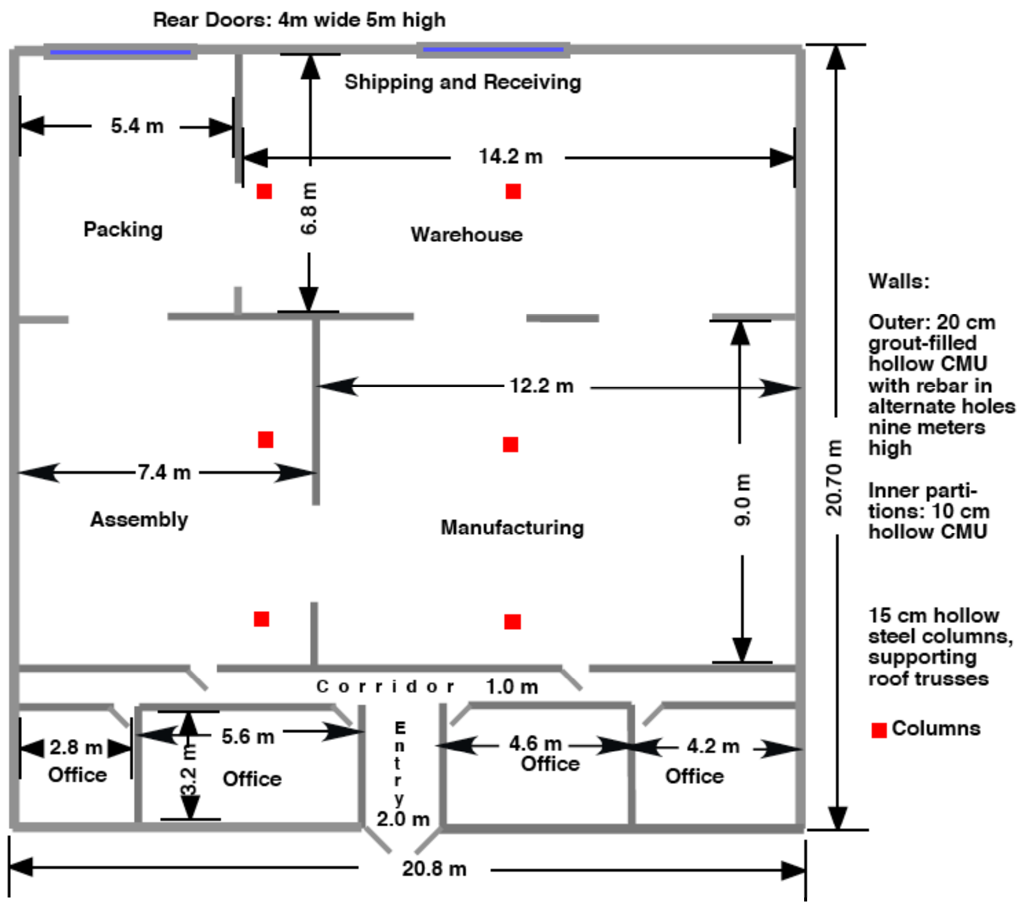


Figure 109. Mass 16-3-a floor plans.

Mass 16-3-b Isometric Floor Plan

CMU Industrial/Storage Building

Commentary

This building is classed as a mass construction structure because of the use of CMU blocks (20 cm thick) to form the outer wall. To provide adequate strength, for this outer wall of 9 meters in height, the blocks must be reinforced with rebar (in every other cavity) and these then filled with grout.

The 20 meter trusses (in blue, and stretching from side wall to side wall) that assist in bearing the weight of the roof, must be supported by columns (in red).

While this example is drawn to a specification of 20 x 20 meters, observation of buildings of this type in various parts of the world suggests that most such structures are longer than they are wide. A typical example would be a structure that is 34 m wide by 40 m long.

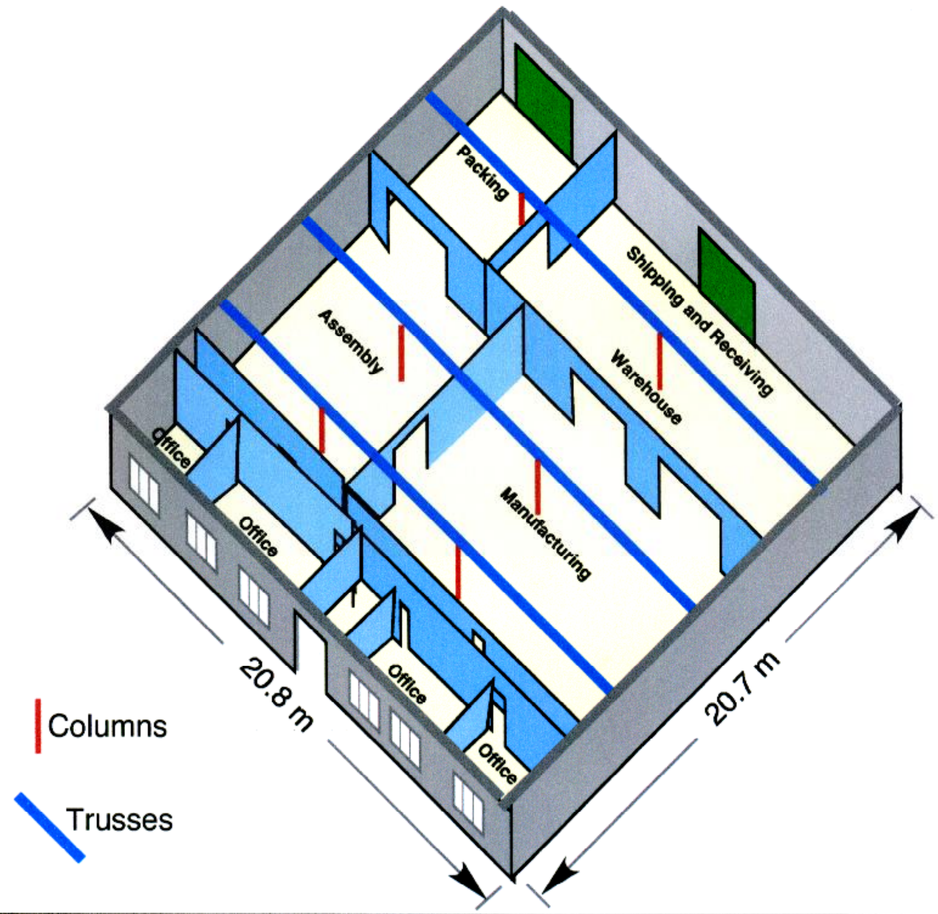


Figure 110. Mass 16-3-b isometric floor plan.

Mass 16-4 Construction

CMU Industrial/Storage Building

Commentary

A CMU wall is strengthened by placing rebar in alternate cavities, and then pouring concrete grout into the cavities.

Rebar in alternate cavities, Filled with Grout: Concrete Masonry Units

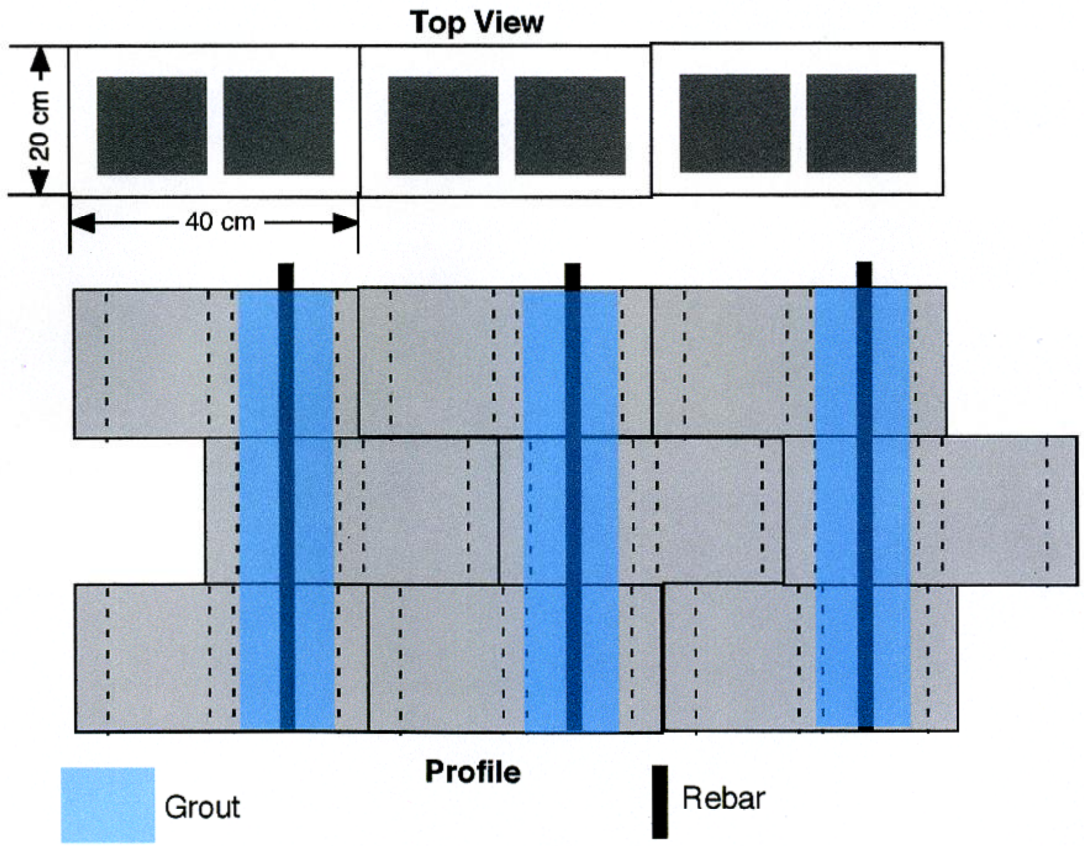
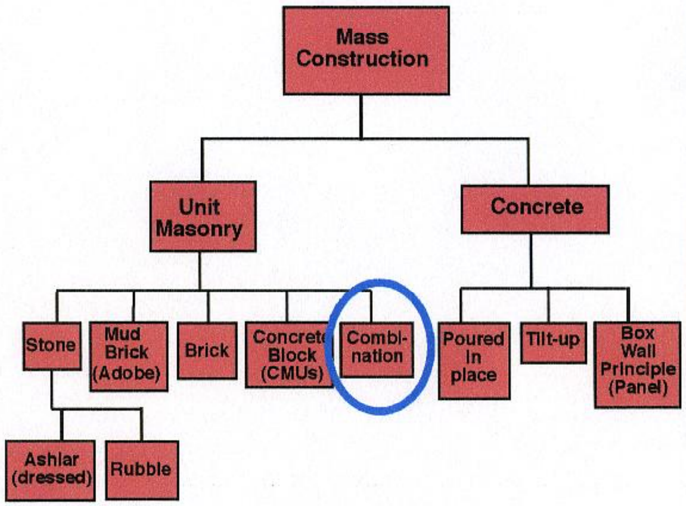


Figure 111. Mass 16-4 construction.

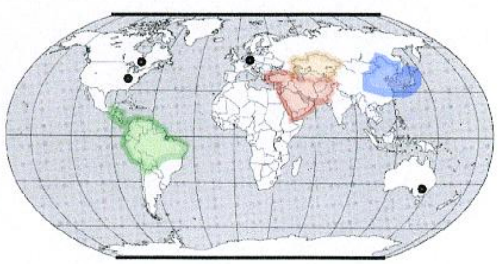
Mass 17-1 Place on Building Construction Chart

Brick over Block House

Place on Building Construction Chart



World locations where brick over block is important



International Example

RE photo.

Brick over block is used in Australia for house construction, as seen in this example. Close look at the brick reveals it to have a facing pattern (only stretchers) indicating it is only one wythe thick.

Figure 112. Mass 17-1 place on building construction chart.

Mass 17-2 Elevation and Construction

Brick over Block House

Commentary

Here, a brick layer covers concrete masonry units (CMUs) to provide protection from the elements. Exposed are the sides of stretchers, laid in what is called a facing pattern. The brick layer is 11.5 cm thick. Total wall is 32.5 cm thick, given 1 cm thickness of mortar. The CMU blocks, along with the perimeter foundation are load-bearing; the brick layer is but a veneer. Note: bricks rest upon an extension of the concrete perimeter foundation but are not load bearing.

CMU wall commonly employs strengthening with rebar placed through some of the cavities, then filled with grout.

Brick Covering Concrete Masonry Units (CMUs)

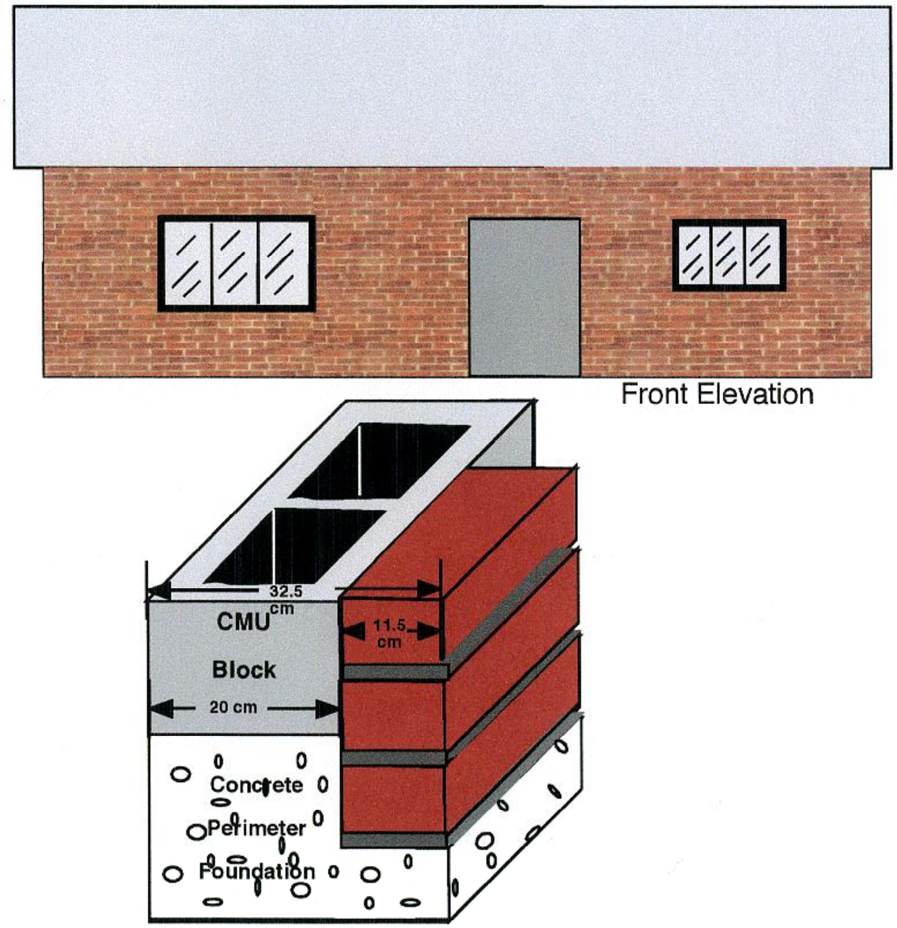


Figure 113. Mass 17-2 elevation and construction.

Mass 17-3-a Floor Plan and Construction

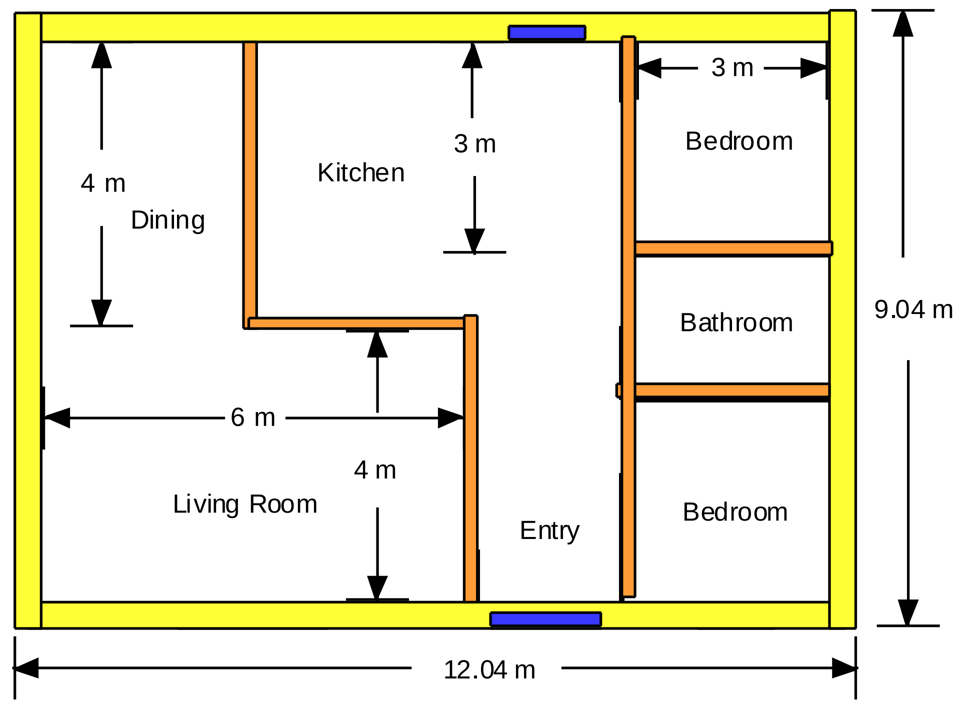
Brick over Block House

Commentary

In the exterior (perimeter) walls, the 20 cm thick CMU blocks bear the weight of the walls, roof, and live load. The combined brick over block (with mortar) reaches 32 cm thick.

The interior walls are 20 cm (one block thick). They form the support for ceiling joists.

Exterior and Interior Walls



Windows

Doors

Brick over Block 32 cm thick perimeter walls

Block 20 cm thick interior walls

Figure 114. Mass 17-3-a floor plan and construction.

Mass 17-4 Construction

Brick over Block House

Load bearing walls

Commentary

In this full two story example, in Costa Rica, a concrete beam has been placed at the top of the row of CMUs of the ground floor as a place to connect a concrete slab floor/ceiling. The same sort of column has been built on the top of the second floor (note the forms have not been removed on the left side). A truss supported roof is in the process of construction. As can be seen in the photo, only the CMUs are an integral part of the structure. The brick facing is applied as a decorative and weather resistant cover.

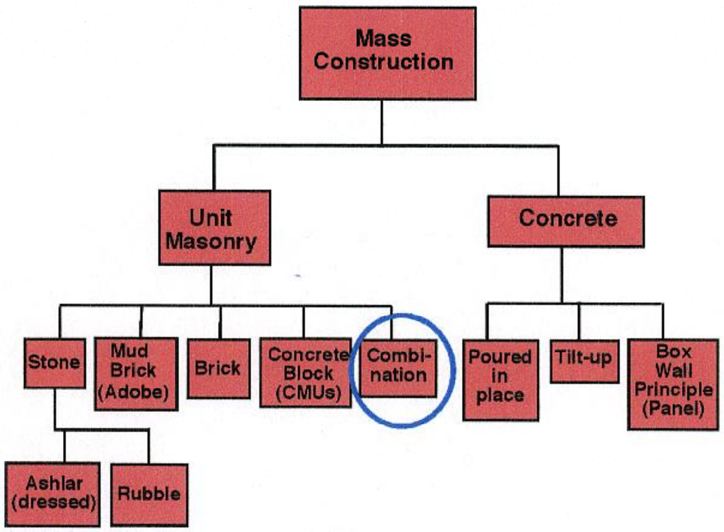
Two story CMU house under construction in Costa Rica. *RE photo.*

Figure 115. Mass 17-4 construction.

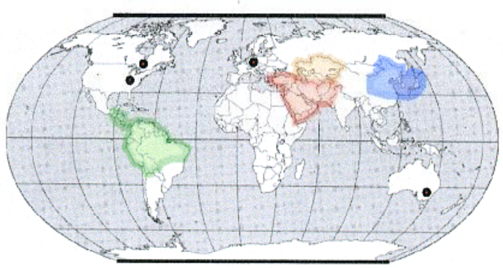
Mass 18-1 Place on Building Construction Chart

Mass Construction (Brick over German Building Block) 1 1/2 Story House

Place on Building Construction Chart



World locations where brick over block is important



International Example

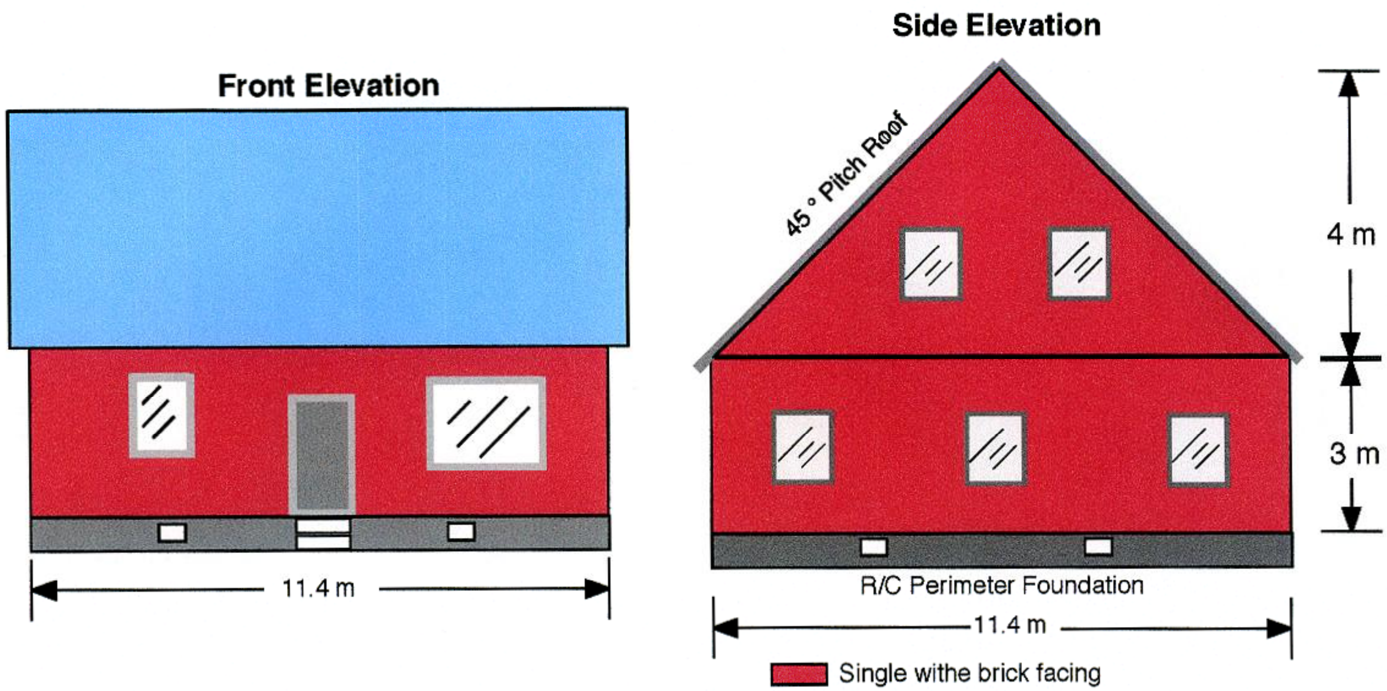
RE photo.

This house, in Germany, is being constructed of light building block (*lichtbaustein*) for the load-bearing exterior walls, and the load-bearing interior walls; brick will be applied as a weather sealant. Note: lintels above windows; 45 ° roof; rafter spacing; and r/c perimeter foundation.

Figure 116. Mass 18-1 place on building construction chart.

Mass 18-2 Elevation

Mass Construction (Brick over German Building Block) 1 1/2 Story House

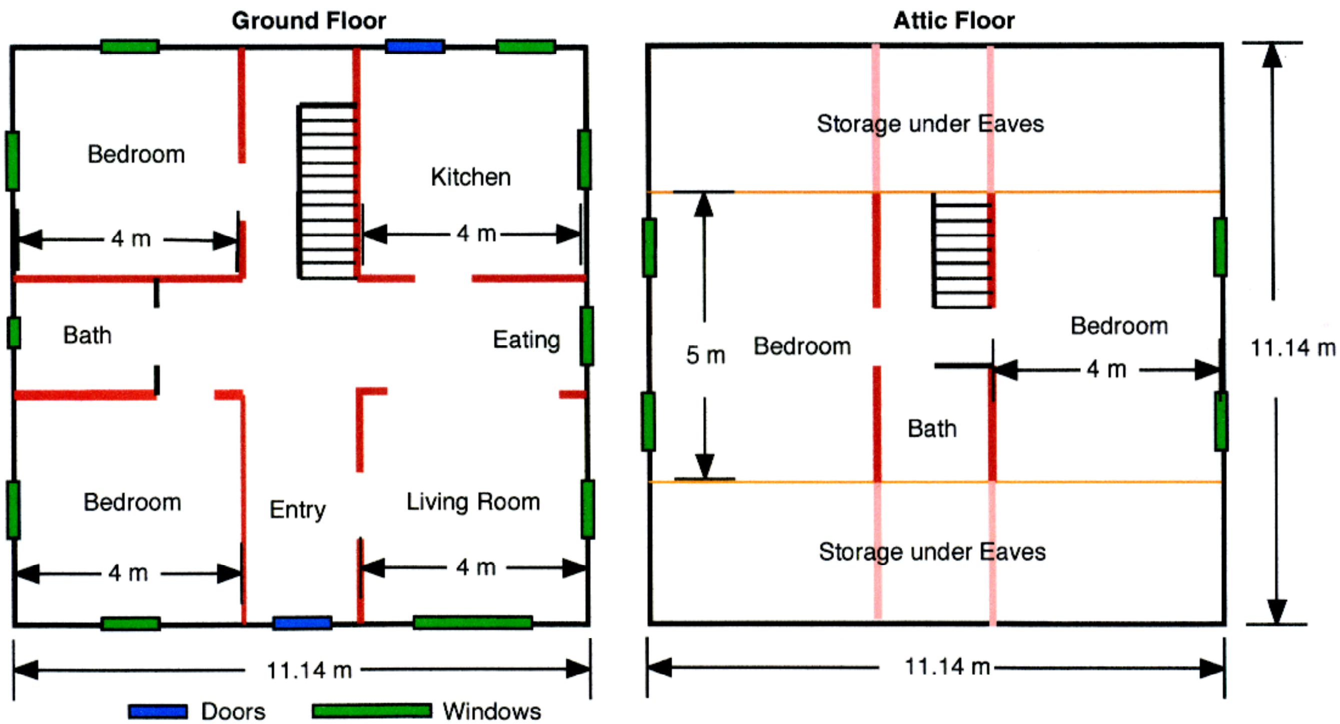


Commentary Simple but utilitarian architectural style is employed in the design of this house. Ground floor space is 100 square meters; the attic has another 50 square meters, and the basement has another 100 square meters, and is used for storage, laundry, and utilities. The living area (ground floor and attic) thus have about 1500 square feet, with the basement space a bonus. Space is adequate for a family of four. The upper floor and the basement also make maximal use of house heating, an item of key concern in European winters.

Figure 117. Mass 18-2 elevation.

Mass 18-3-a Floor Plan

Mass Construction (Brick over German Building Block) 1 1/2 Story House



Commentary

This very common European single-family dwelling shows practicality and economy of construction as provision of interior space in multiple floors on the same footprint and is cheaper than the same amount of interior space spread over a single story dwelling. The attic serves well as bedroom space, and a cellar underlying the entire 11.14 by 11.14 meter structure gives storage space. Rooms are generally on the small side.

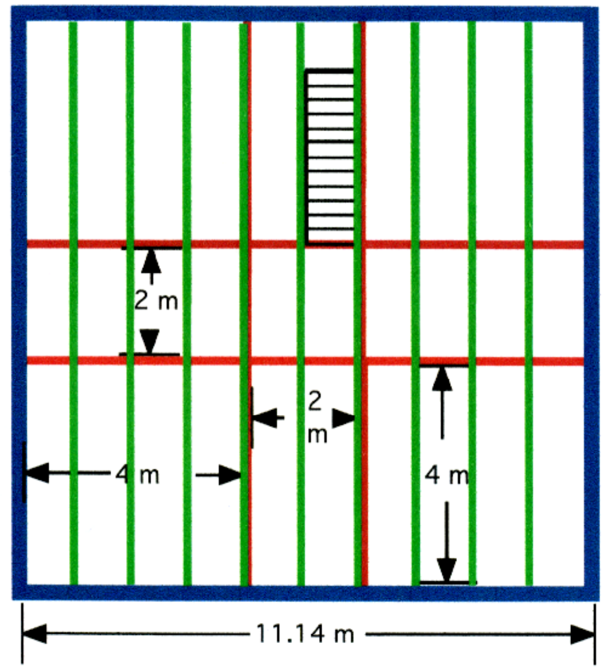
Figure 118. Mass 18-3-a floor plan.

Mass 18-4-a Construction

Mass Construction (Brick over German Building Block) 1 1/2 Story House

Construction Basics: Floor-Ceiling Joists

Ground Floor



Commentary

This mass construction building uses light building block 23 cm thick, faced with brick for sealant against the elements. Interior walls (23 cm thick for the ground floor) are made with light building block, and 11.5 cm bricks are used for the interior walls in the attic floor.

floor/ceiling joists

Exterior load-bearing wall "light building block" is 23 cm thick; facing brick is 11.5 cm, for a combined 35.5 cm thick

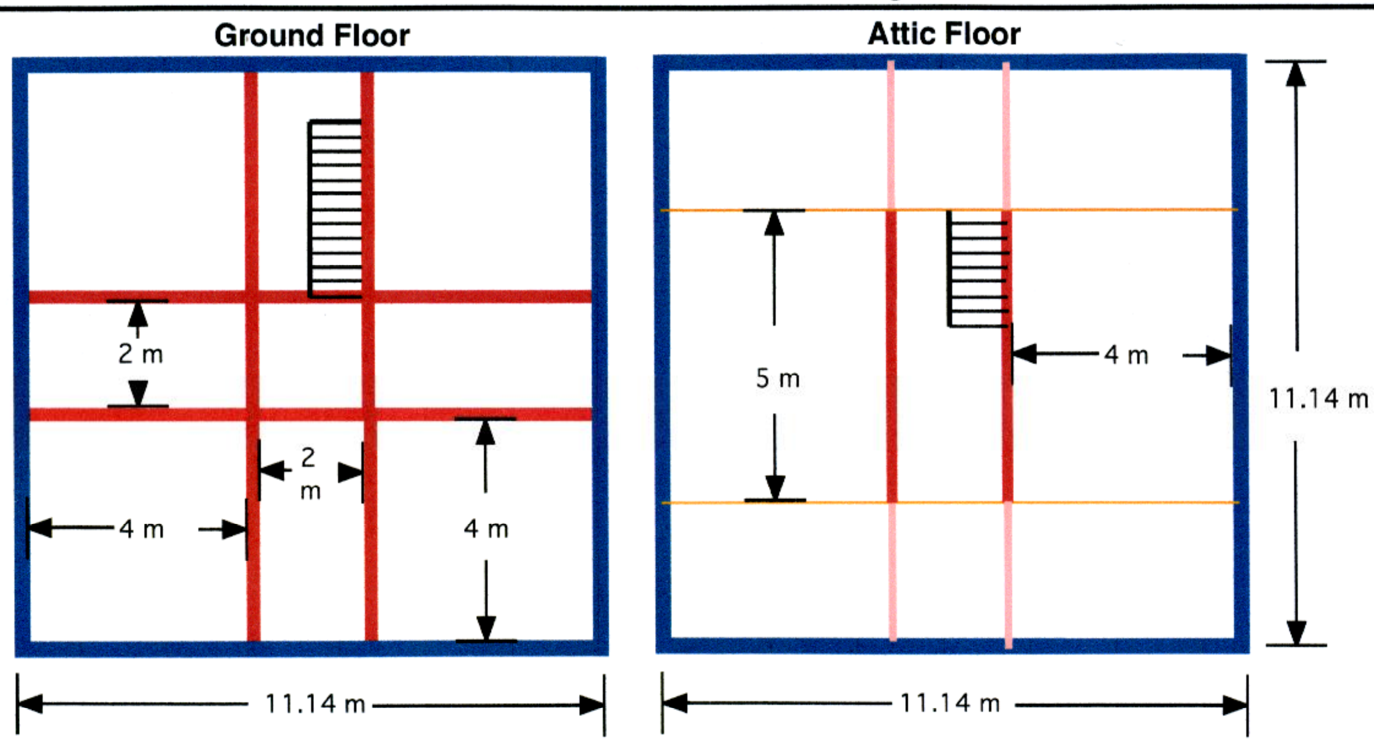
Interior load-bearing wall 23 cm ground floor, 11.5 cm attic floor

Figure 119. Mass 18-4-a construction.

Mass 18-4-b Construction

Mass Construction (Brick over German Building Block) 1 1/2 Story House

Construction Basics: Load-Bearing Walls



Commentary

This mass construction building uses light building block 23 cm thick, faced with brick for sealant against the elements. Interior walls (23 cm thick for the ground floor) are made with light building block, and 11.5 cm bricks are used for the interior walls in the attic floor.

Exterior load-bearing wall light building block is 23 cm thick; facing brick is 11.5 cm thick, for a combined 35.5 cm.

Interior load-bearing wall 23 cm ground floor, 11.5 cm attic floor

Figure 120. Mass 18-4-b construction.

Mass 18-4-c Construction

Mass Construction (Brick over German Building Block) 1 1/2 Story House

Construction: Light Building Block with Brick Cover

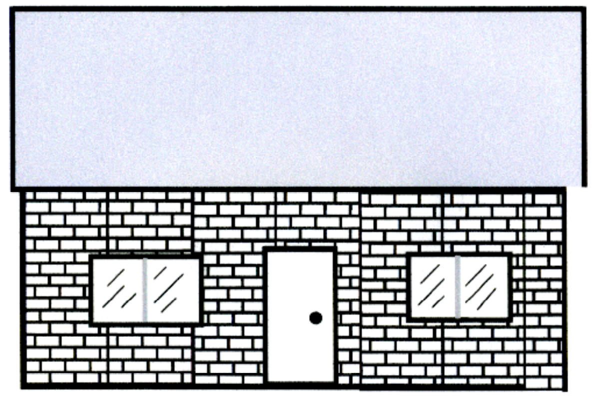
Commentary

A form of mass construction common in Western Europe employs a large (46 x 23 x 23 cm) building block made of composition materials and light in weight. These blocks are not formed with holes for the placement of rebar; their large size alone provides the necessary strength to uphold all structural loads.

Their light material, however, requires a protective cover from the elements. Stucco is often used, and in this example, courses of brick are mortared to the building block.

This front elevation shows the windows for the living room on the left and the dining room on the right, with the front entry door in the middle.

Front Elevation



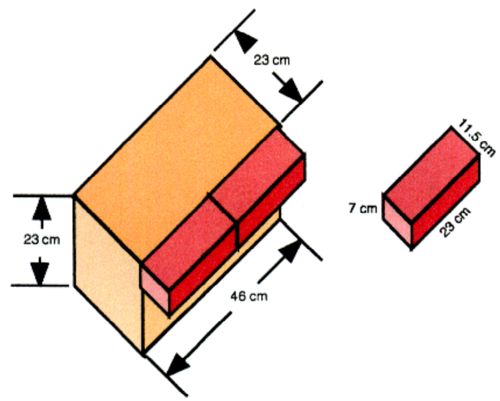
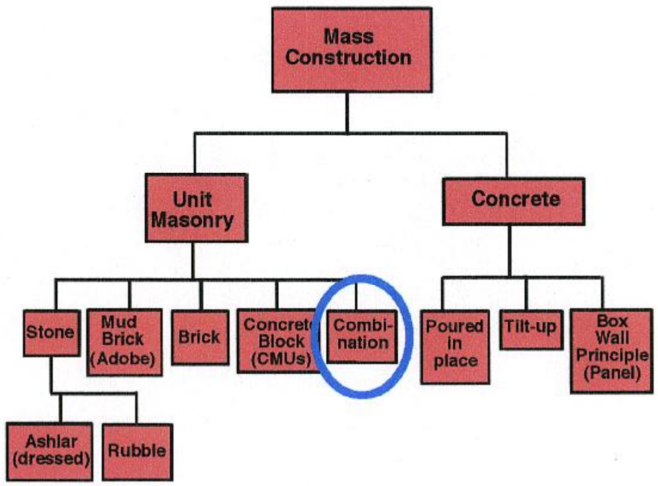


Figure 121. Mass 18-4-c construction.

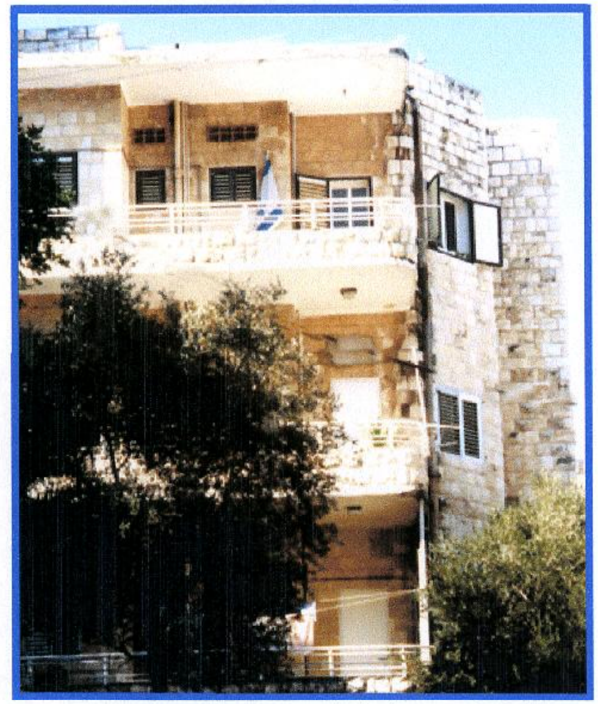
Mass 19-1 Place on Building Construction Chart

Unreinforced Concrete with Masonry Cover

Place on Building Construction Chart



International Example



RE photo, 1999.

Three story, stone veneered apartment building in Haifa, Israel, is an example of a popular style in this city. The type is found in both Israel and on the West Bank, and is of the same type as reported in the World Housing Encyclopedia.

Figure 122. Mass 19-1 place on building construction chart.

Mass 19-2 Elevation

Unreinforced Concrete with Masonry Cover

Commentary

This elevation of a type of construction found in Israel and the Palestinian Territories manifests many aspects of local, contemporary culture. The use of stone (over concrete) is largely a cosmetic feature designed to be compatible with traditional stone construction. The balconies are a common feature of dwellings in the area, reflecting an indoor/outdoor style. The parking garages on the ground floor are modern necessities with the current high automobile ownership found among the economic class of people capable of affording housing of this quality.

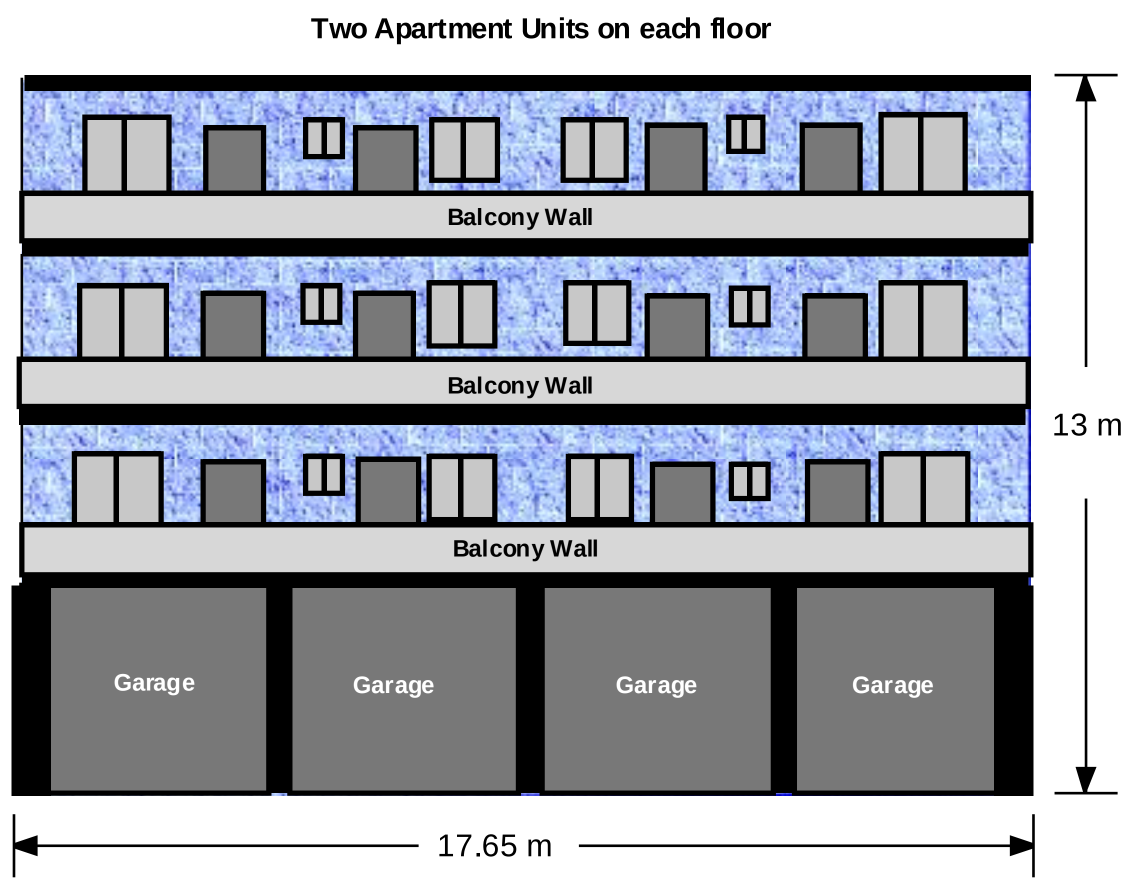
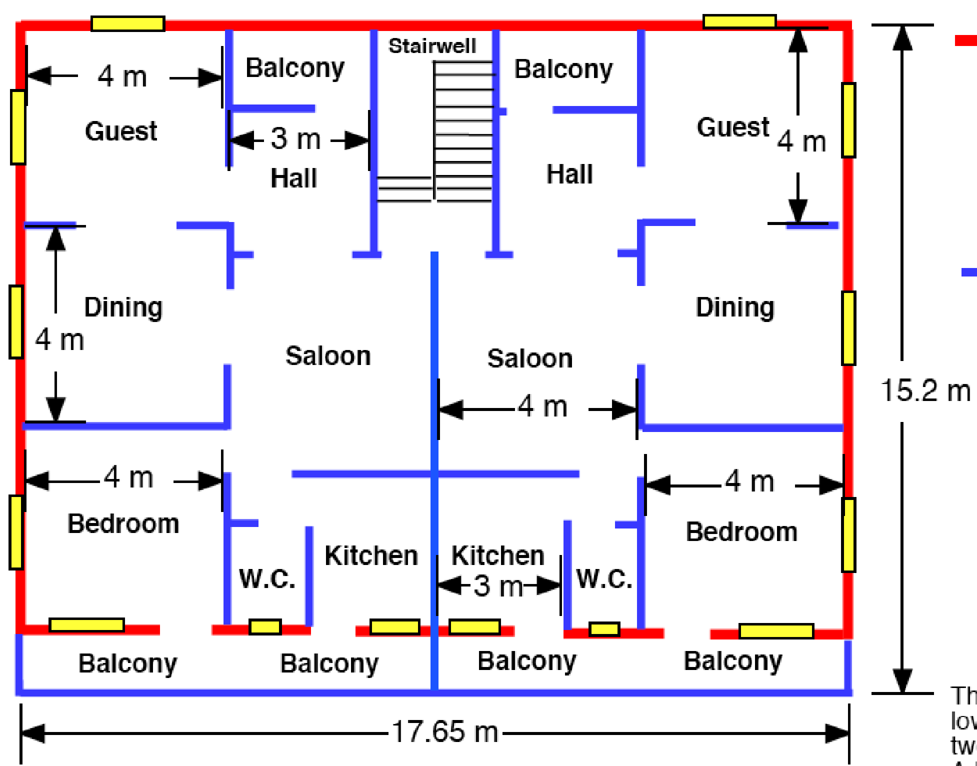


Figure 123. Mass 19-2 elevation.

Mass 19-3-a   Floor Plan

Unreinforced Concrete with Masonry Cover

Floor Plan for each of Three Floors



Load-bearing exterior unreinforced concrete (30 cm with a 15 cm stone veneer) (see diagram, Mass 19-4)

Plain concrete (unreinforced) interior load-bearing walls (15 cm thick)

Windows

This is a type found in Palestine and Israel (see photo, Mass 19-1, of an Israeli example in Haifa).

Commentary

The floor plan of these apartments follows a conventional design. Entry to the two is by stairs in between the two units. A long balcony fronts bedroom and kitchen on one side, a small balcony is on the other side. Units have five rooms each, counting the kitchens. Plumbing is aligned between bath and kitchen.

Figure 124. Mass 19-3-a floor plan.

Mass 19-3-b Isometric Floor Plan

Unreinforced Concrete with Masonry Cover

Floor Plan for each of Three Floors

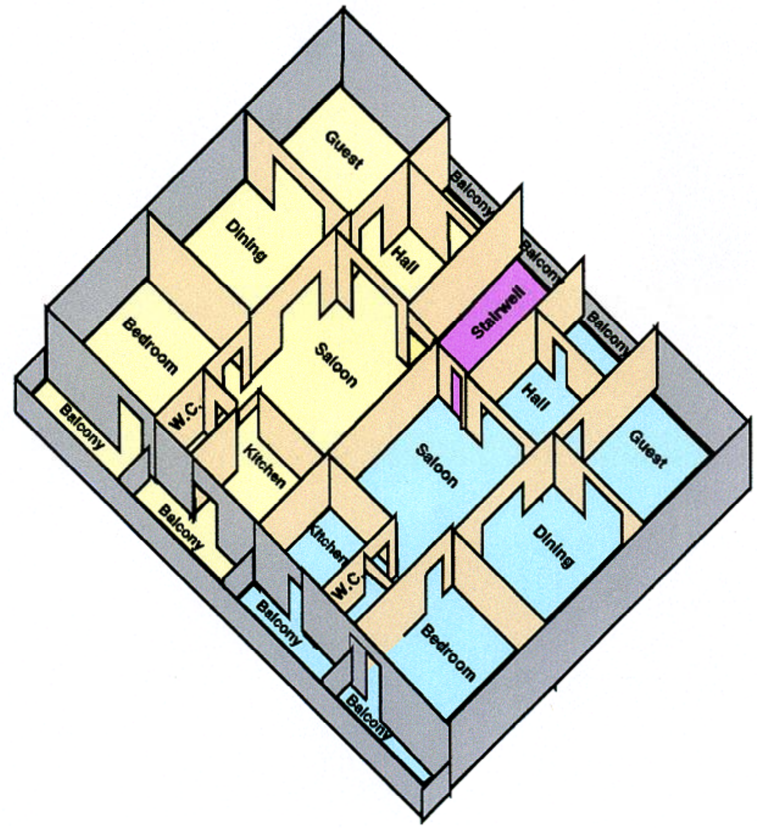
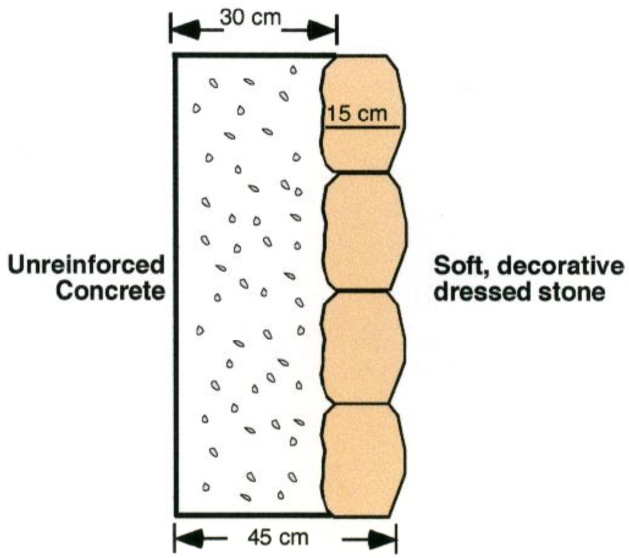
Commentary	Three floors with apartments
This perspective view provides, in conjunction with the two dimensional floor plan, ready understanding of the building's spatial interior arrangement, and how rooms may be accessed by troops entering the building.	

Figure 125. Mass 19-3-b isometric floor plan.

Mass 19-4 Construction Method and Dimensions

Unreinforced Concrete with Stone Cover

Exterior wall cross-section



Example in Israel

RE photo.

Decorative stone being applied over a concrete wall. The concrete load-bearing wall provides supporting strength, the various shaped stone forms a veneer. In Haifa, Israel.

Commentary	Cross section of load-bearing exterior wall. Unreinforced concrete and masonry apartment building. Walls are very thick but stone is soft and concrete is not reinforced with steel.

Figure 126. Mass 19-4 construction method and dimensions.

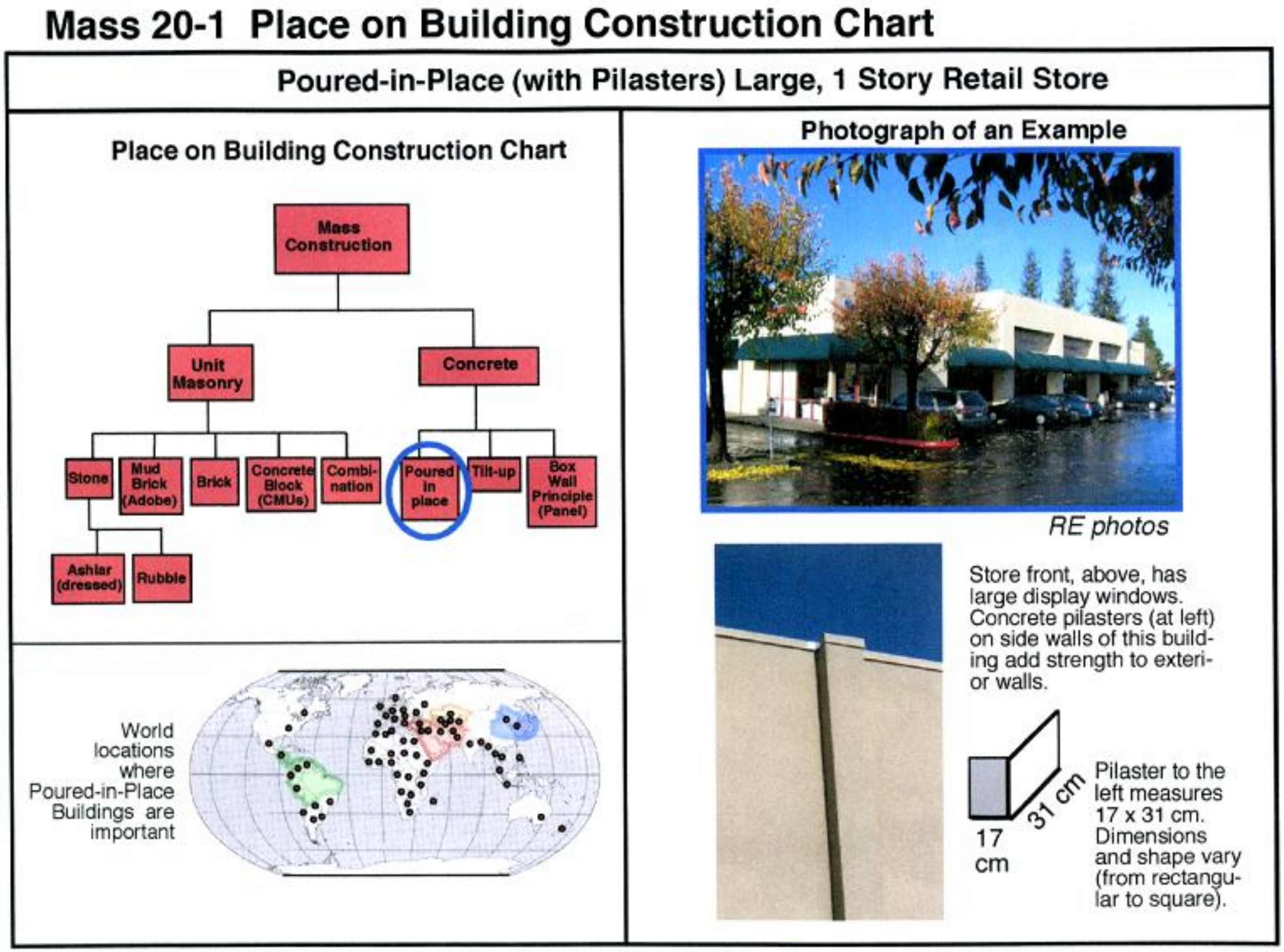


Figure 127. Mass 20-1 place on building construction chart.

Mass 20-2 Elevation

Poured-in-Place (with Pilasters) Large, 1 Story Retail Store

Elevations

Commentary

These two elevations, front and one side, show the locations of the pilasters, and the nature of the construction of the roof trusses. The roof extends 1.5 meters above the top of the wall.

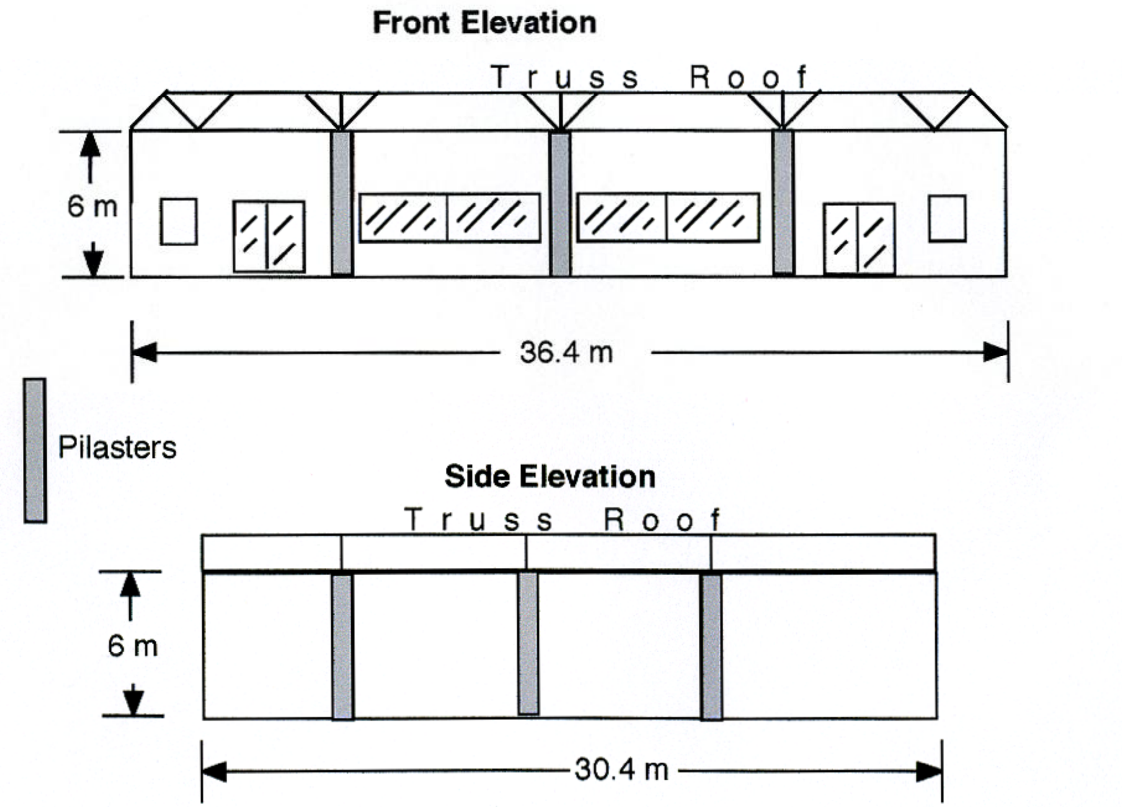


Figure 128. Mass 20-2 elevation.

Mass 20-3-a Floor Plan

Poured-in-Place (with Pilasters) Large, 1 Story Retail Store

Commentary

Large footprint stores — classed as "commodity combining," as a super market, and now found worldwide — require the closing in of considerable areas and volumes of unobstructed space (except for support posts). Bearing the load of the wide roof requires strong walls, achieved in this example by the addition of *pilasters* to the reinforced concrete walls as they are poured in situ. These pilasters also anchor the roof trusses (see construction panel). Separate space at the rear is required to house stock.

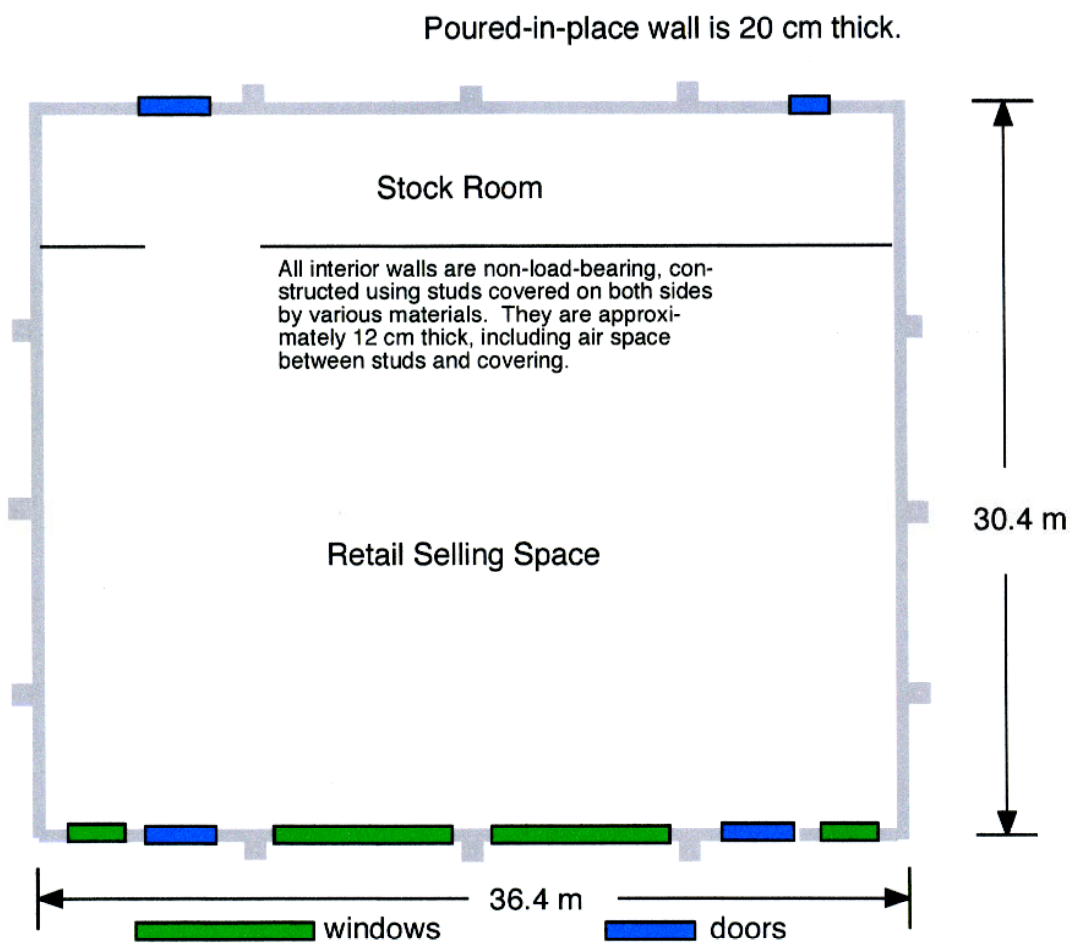


Figure 129. Mass 20-3-a floor plan.

Mass 20-4 Construction

Poured-in-Place (with Pilasters) Large, 1 Story Retail Store

Construction Characteristics

Commentary

The poured-in-place walls, reinforced by pilasters, support the load of the wall itself and the trusses to support the roof. The trusses are steel with braces. Trusses require some additional support to cover the entire 36 m length, achieved through the use of steel posts mounted 9 meters apart.

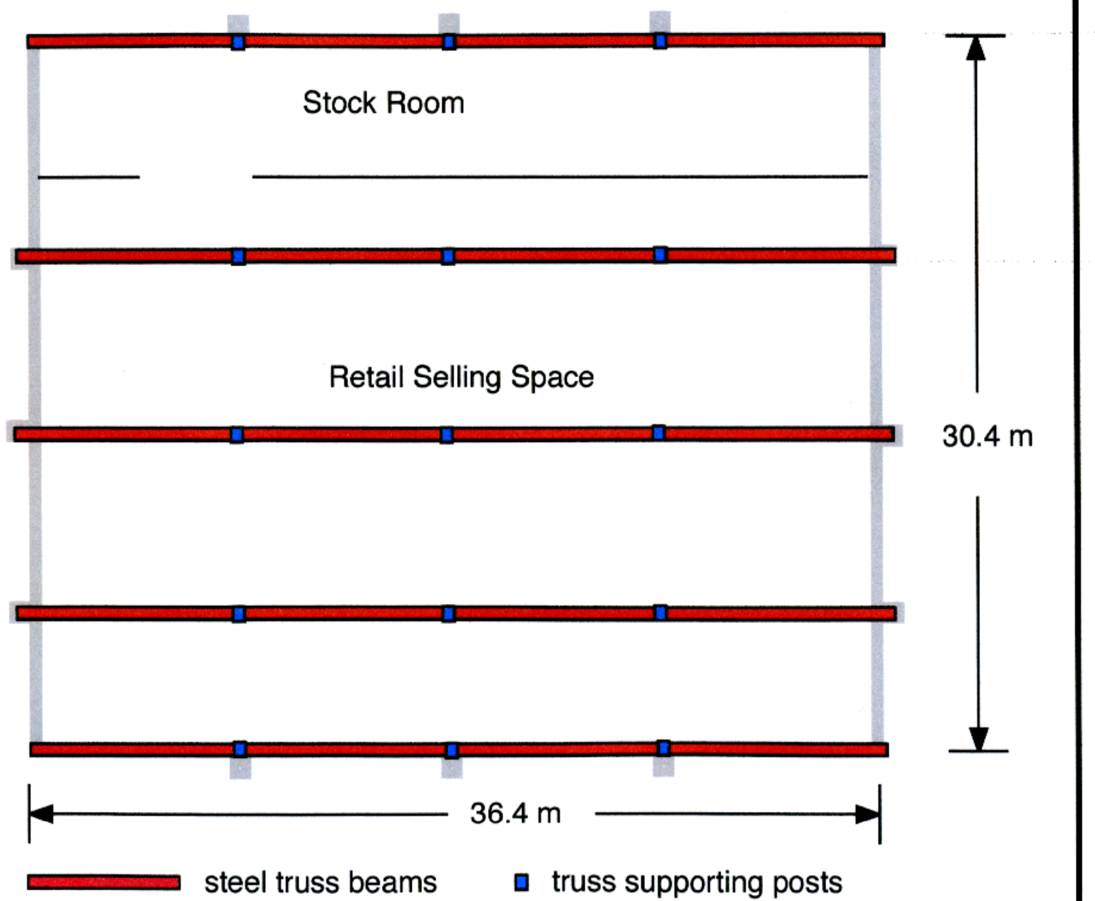
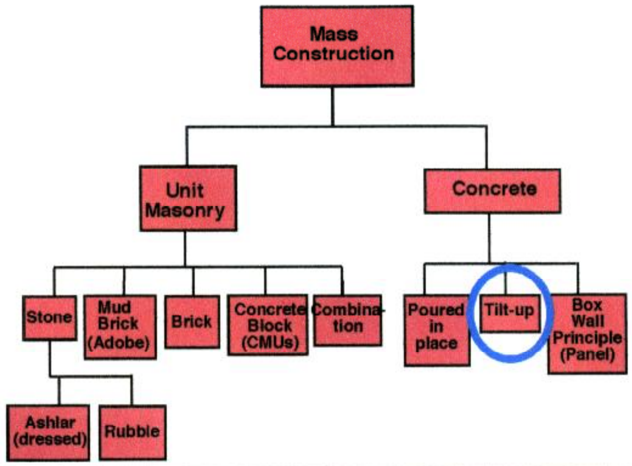


Figure 130. Mass 20-4 construction.

Mass 21-1 Place on Building Construction Chart

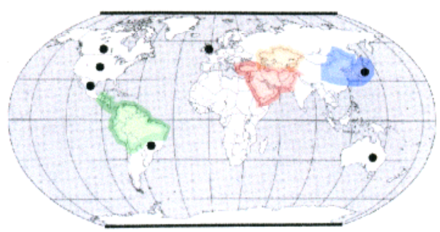
Tilt-up Manufacturing/Storage Building

Place on Building Construction Chart



Reinforced concrete panels are either poured-in-place on the structure's floor and then "tilted up" or built off-site in a factory and transported to the building site. The above photo shows an early form of the art; the lower photo expresses the evolution into two (and sometimes three) story tilt-ups. Venting (windows and doors) are formed during the pouring process.

World locations were Tilt-ups are important



Photographs of Examples

RE Photos

Figure 131. Mass 21-1 place o n building construction chart.

Mass 21-2   Elevations

Tilt-up Manufacturing/Storage Building

Commentary

Tilt-up buildings used for manufacturing and storage often have little need for venting. Large doors for truck and fork-lift vehicles are seen at both front and rear. Small doors are for human entrance. The single window at the front elevation provides venting and light for the office.

The walls, in this example, reveal the bare concrete of the tilt-up panels.

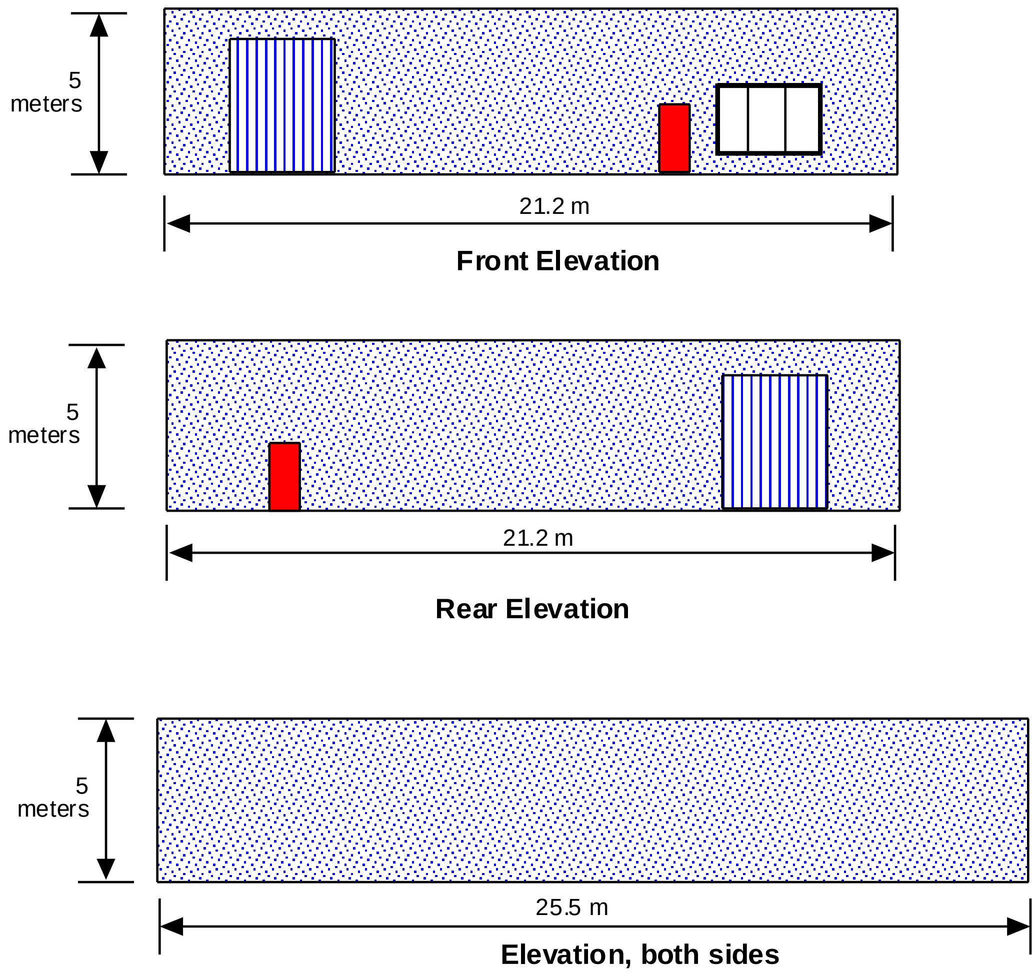


Figure 132. Mass 21-2 elevations.

Mass 21-3-a Floor Plan

Tilt-up Manufacturing/Storage Building

Commentary

Manufacturing/storage buildings constructed in the last 50 years have taken a shape that meets the need for access by truck. Older buildings reflected their particular needs, e.g., high-rise structures were constructed at water power sites, and buildings with long sides were built parallel to railroad lines to access several railroad cars at the same time.

These modern buildings have large doors for truck access (height of about 4 m, and width of 3 m).

In common with older structures is the need for both large planimetric floor space and height. Lighting is often achieved through use of skylights.

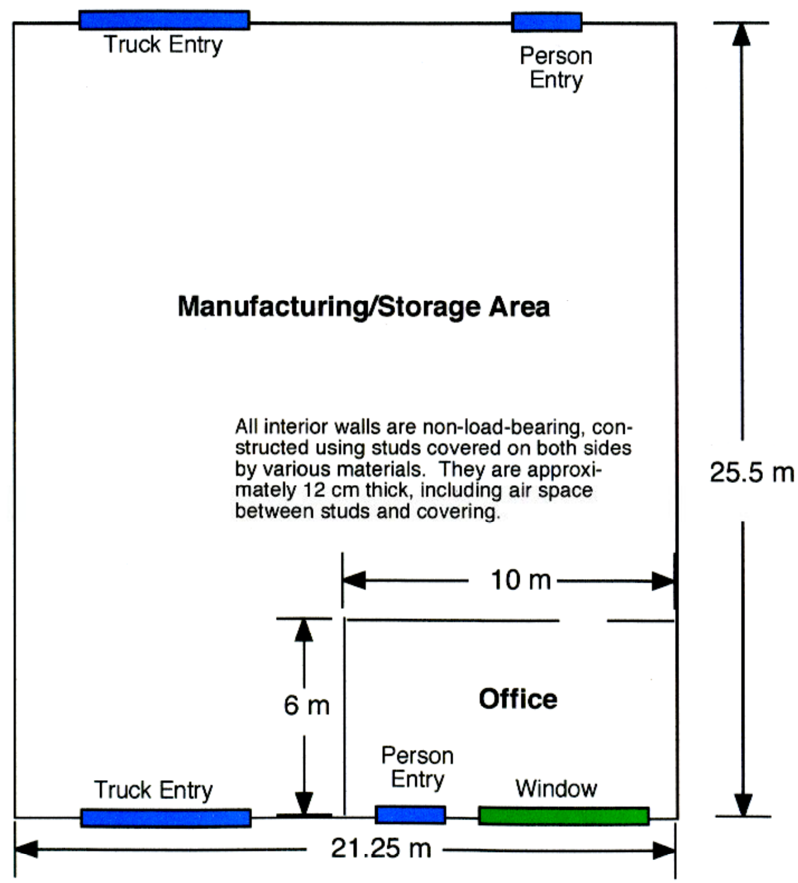


Figure 133. Mass 21-3-a floor plan.

Mass 21-4-a Construction

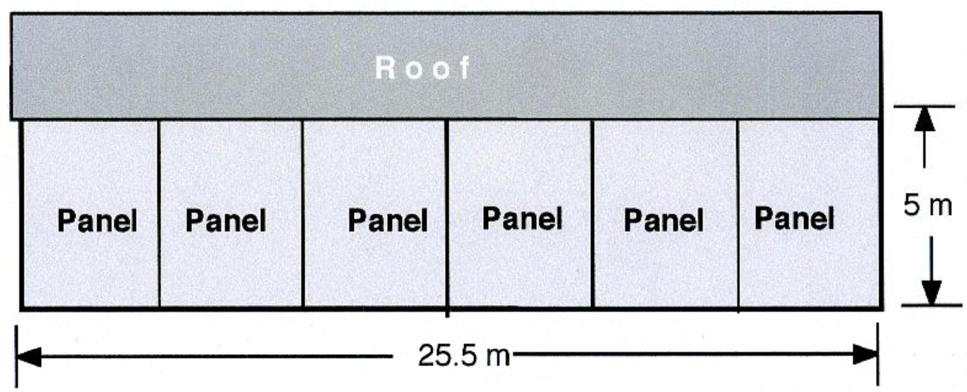
Tilt-up Manufacturing/Storage Building

Commentary

This side elevation of a tilt-up reinforced concrete wall building shows the joints of the panels. These are connected with welded rebar joints. In some cases, load-supporting columns are placed at joints.

Side elevation has no venting. All venting is at both ends using the same format as illustrated with the framed buildings with infill examples.

Side Elevation



Tilt up panels: Six 4.25 m panels

Figure 134. Mass 21-4-a construction.

Mass 21-4-b Construction

Tilt-up Manufacturing/Storage Building

Commentary

This variant employs reinforced concrete walls, poured-in-place on the building's floor, and then "tilted-up," braced, and then secured. Panels are 4 meters wide for the side walls (requiring six 4.25 m panels to attain the 25.5 m length). Five end panels of 4.25 meters each are used for the end walls.

The floor space is enclosed, without supporting posts within, by roof trusses resting on the side tilt-up walls.

Tilt-up walls are 20 cm thick.

Trusses rest on perimeter walls, and also receive some support from 10 cm hollow steel columns.

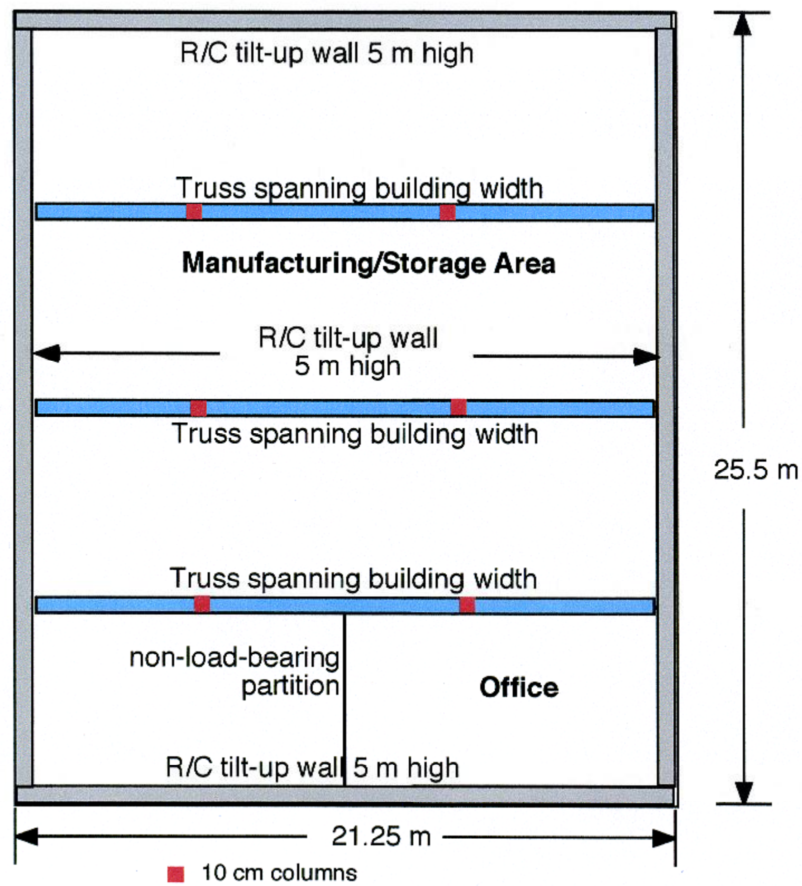
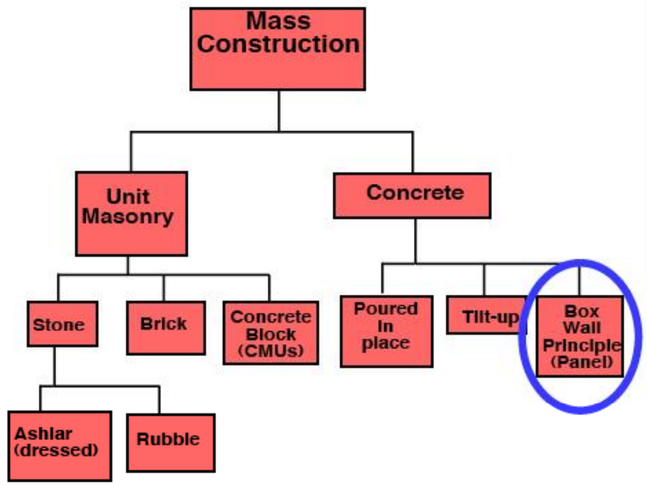


Figure 135. Mass 21-4-b construction.

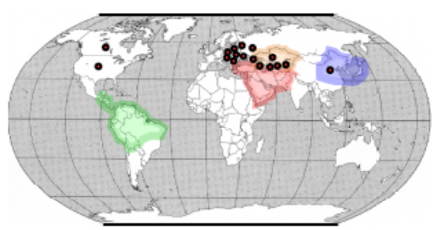
Mass 22-1 Place on Building Construction Chart

Box-Wall Principle Apartment Building

Place on Building Construction Chart



World locations where Box Wall/ Panel Buildings are Important



International Example

RE photo 2004

This panel wall structure is part of a complex built in Prague during 1945 to 1990. It has three sets of apartments (note stairways and entrances).

Commentary

For Box-wall Principle reinforced concrete, walls and ceiling/floors are made in factories into panels in sizes determined by building plans and then transported to the construction site. They are classed as mass structures because the walls are load bearing though such buildings may be mis-taken for framed light-clad buildings when observed in the field.

Figure 136. Mass 22-1 place on building construction chart.

Mass 22-2 Elevation

Box-Wall Principle Apartment Building

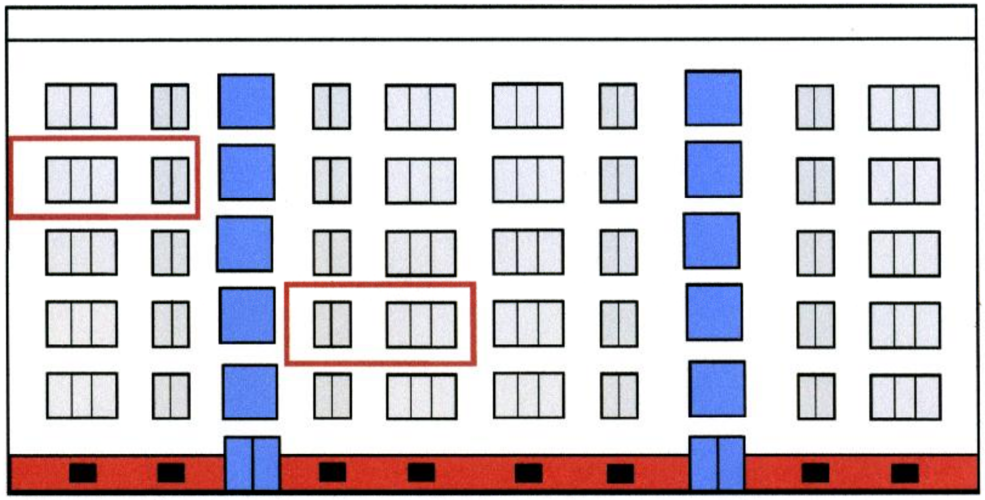
Commentary

Apartment buildings of this sort, built widely in the USSR and in territories under its control in the period from 1945 through 1990, were very uniform in construction and internal apartment unit configuration. This example building has twenty apartment units. The building has two stairway modules. Entry doors for two units face each other across the entry module containing the staircase; the building has no elevators. Each unit has one wide window and one narrow window facing the street.

Room sizes within are box-wall modules (each with r/c walls, floors, and ceilings).

Front Elevation

Example apartment units



Stair, entry module

Two examples, in Prague, 2004.
Panel joints can be seen on both.
RE photos

Figure 137. Mass 22-2 elevation.

Mass 22-3-a Floor Plan

Box-Wall Principle Apartment Building

Commentary

This representative three apartment segment of a multi-floor panel construction building in the former Soviet Union demonstrates several characteristics such structures had in common:

(1) the same room widths throughout is a product of using standard concrete panels.

(2) access by stairway, rather than an elevator, is indicative of the low level of the economy. This results in a distinctive floor plan.

(3) balconies are a common design feature. They have walls 1 m high, 16 cm thick.

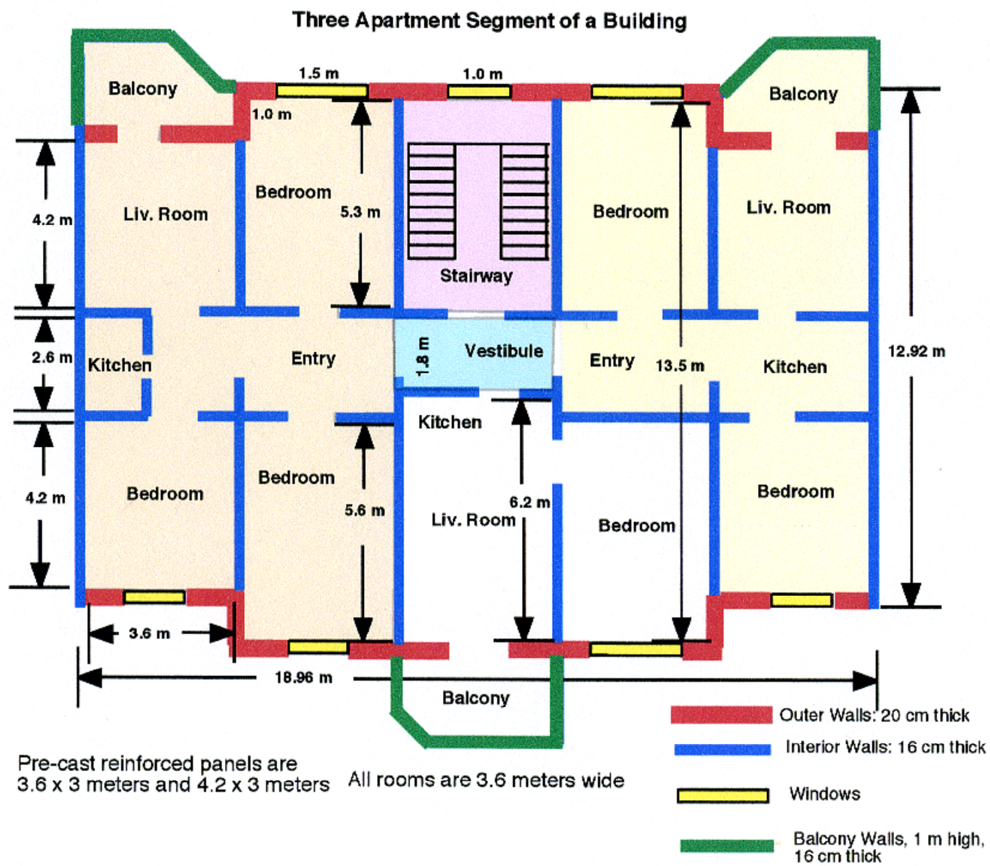
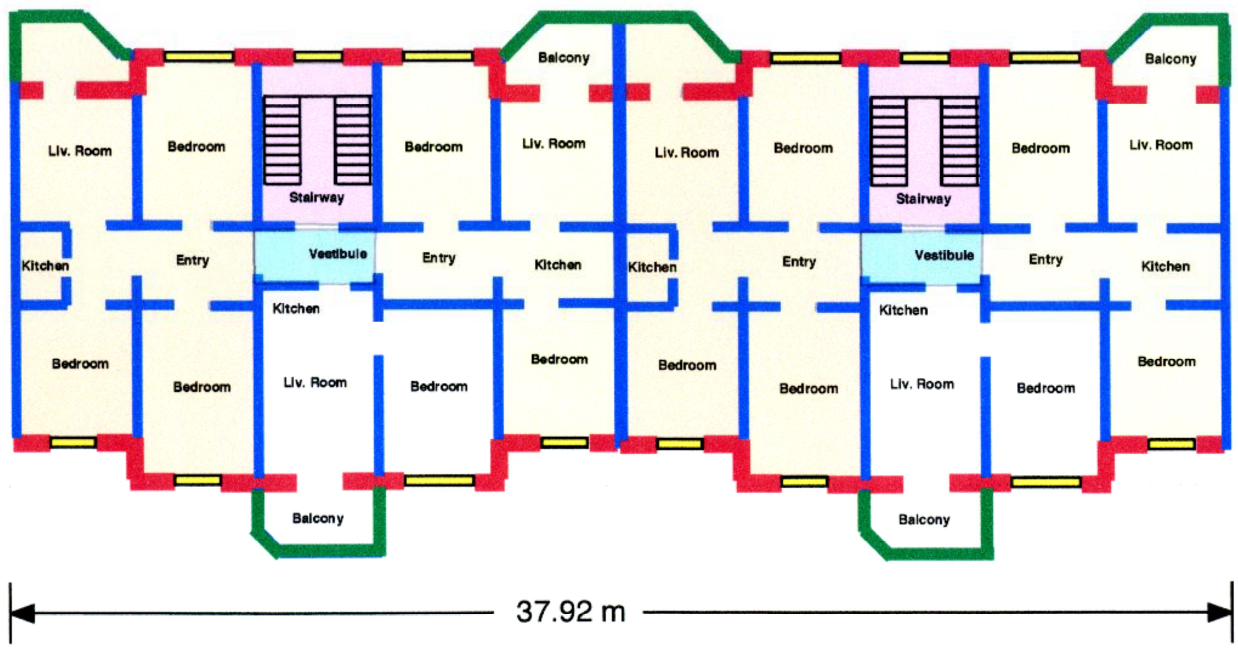


Figure 138. Mass 22-3-a floor plan.

Mass 22-3-b Floor Plan

Box-Wall Principle Apartment Building

Example of 6 Apartment Units, Upper Floors



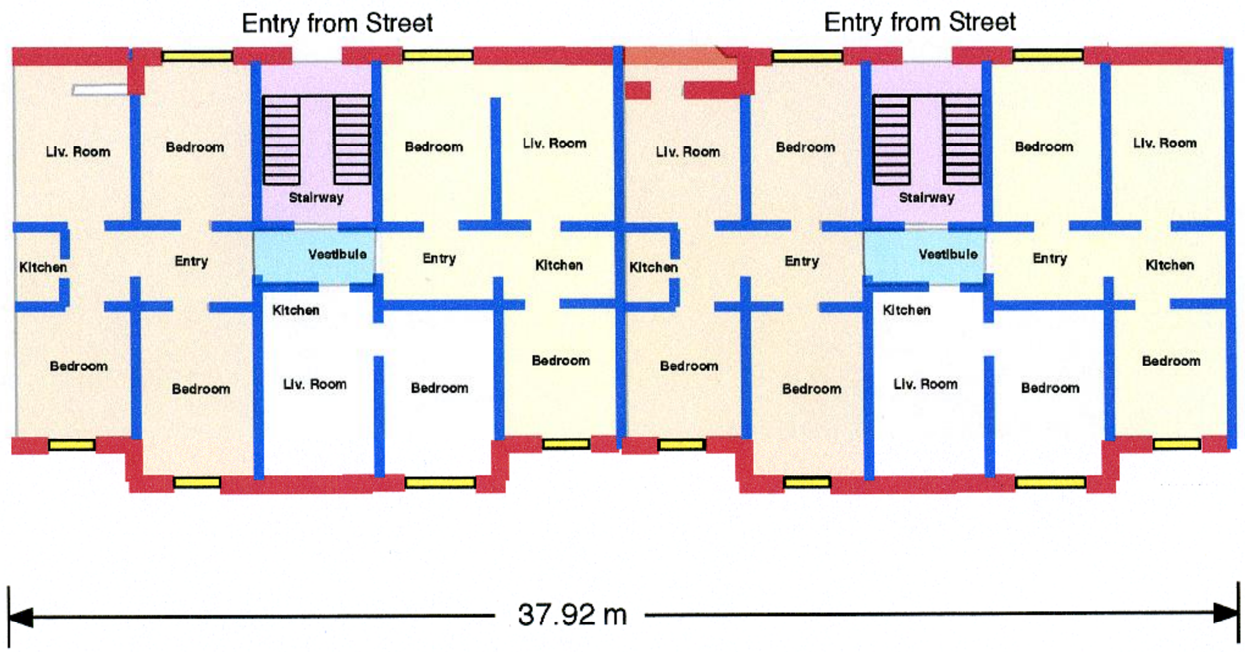
Commentary In this example, two of the modules (in Plate 22-3-a) are connected to demonstrate a common length of such structures; longer single buildings can be achieved through additional increments of three apartment modules. For dimensions, see Plate 22-3-a. Wall connecting modules are the same (16 cm thickness) as are all interior walls, indicating all were built at the same time and are unlike some brick abutted brick buildings that were built independently and where each would have an exterior wall of varying thicknesses.

Figure 139. Mass 22-3-b floor plan.

Mass 22-3-c Floor Plan

Box-Wall Principle Apartment Building

Example of 6 Apartment Units, Ground Floor



Commentary The ground floor differs from the upper floors in that it has the entrances from the street to the ground floor and upper floor apartment units and has no balconies.

Figure 140. Mass 22-3-c floor plan.

Mass 22-3-d Isometric Floor Plan, an Upper Floor

Box-Wall Principle Apartment Building

Commentary

This perspective (45°) isometric view of the floor plan serves to emphasize the features of a plan of an upper floor, i.e., the common stairway and vestibule, the balconies of each apartment and the entry way of each.

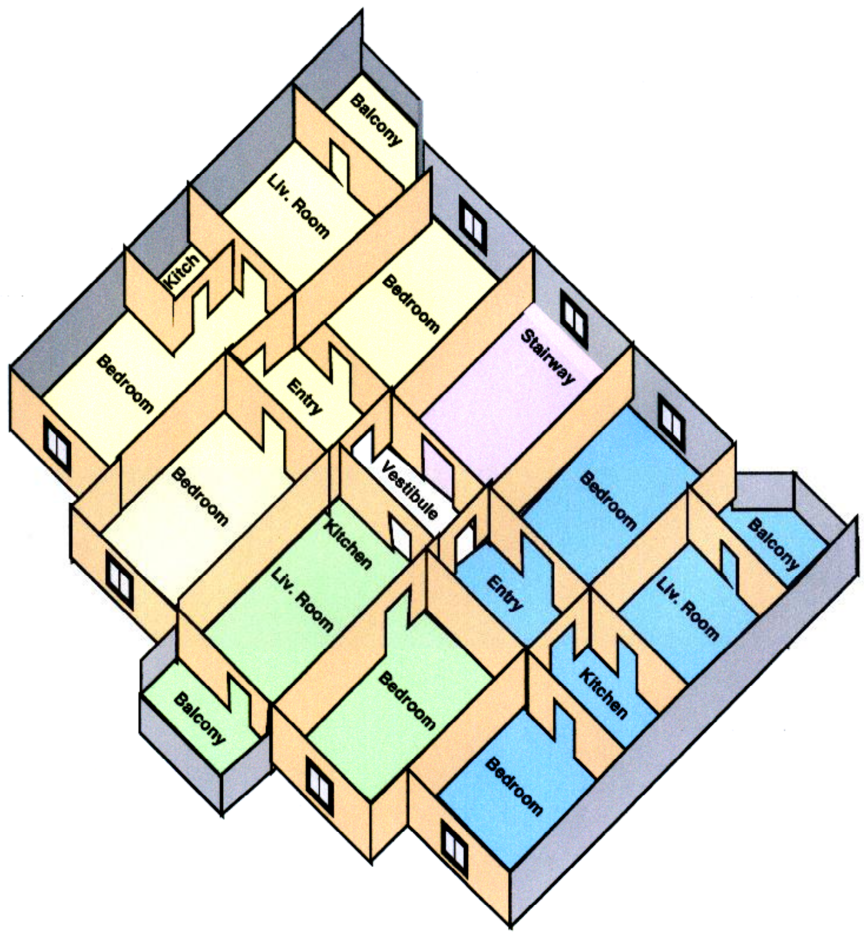


Figure 141. Mass 22-3-d isometric floor plan, an upper floor.

Mass 22-4-a Construction

Box-Wall Principle Apartment Building

Construction Method and Dimensions

Commentary

Factory-built wall and ceiling/floor panels are assembled to create a **Box**. Interior non-load-bearing partitions are used to create divisions of the room.

Construction of a BOX.
Exploded View of Walls
and floor/ceiling

Panels are connected
(with welding and mortar)
during construction.

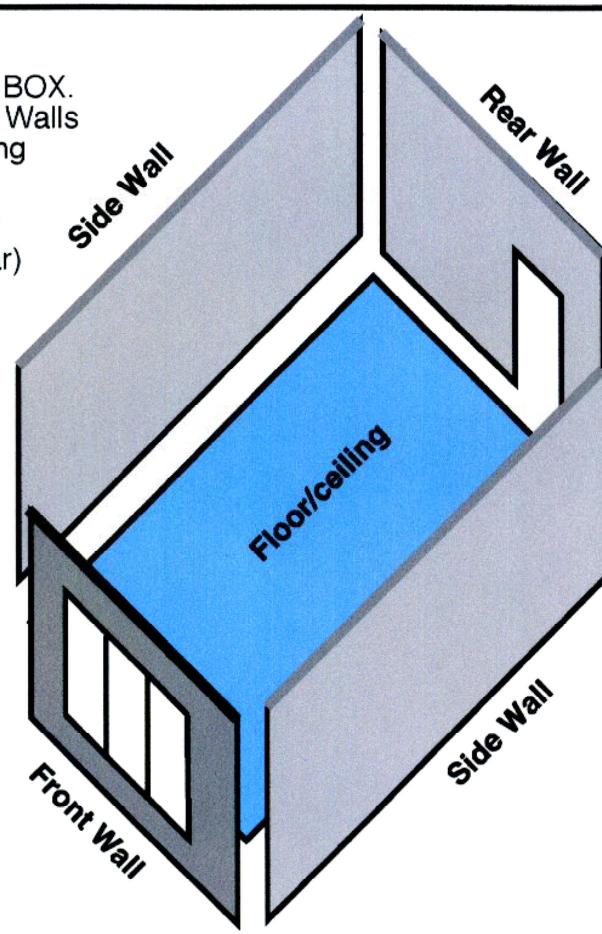


Figure 142. Mass 22-4-a construction.

Mass 22-4-b Construction

Box-Wall Principle Apartment Building

Construction Method and Dimensions

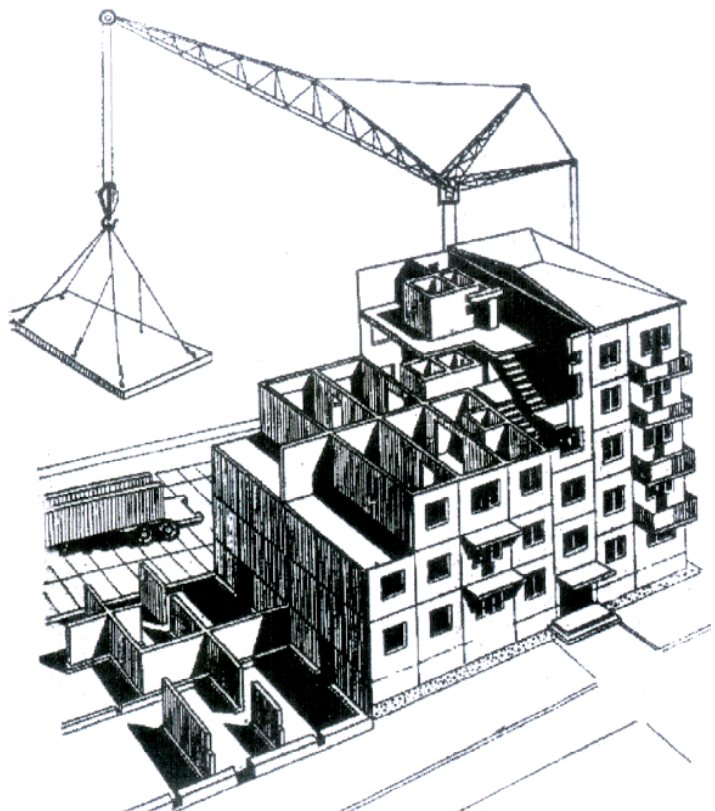
Commentary

Box-wall Principle construction, aka Panel Construction, is a form of Mass Construction, in that all the walls bear the load of the whole building (walls, ceilings, roofs, and live load). The exterior concrete walls are necessarily strong, being 20 centimeters thick and supported with reinforcement bars; interior walls are r/c and 16 cm thick. Panels are usually built off-site in a factory. This construction form is useful when individual "boxes" are used for rooms in apartments, or hotels, and thus where there is no desire to convert them to uses requiring large rooms, e.g., offices, such as is done with framed construction.

Concrete compressive strength is 326 kg/cm^2.

This form is found widely in Russia, former Soviet Republics, and in Eastern European former satellite countries, and is used widely for hotels and apartments worldwide.

Box Wall Principle, or "Panel" Construction



Source: *World Housing Encyclopedia*

Figure 143. Mass 22-4-b construction.

Mass 22-4-c Construction

Box-Wall Principle Apartment Building

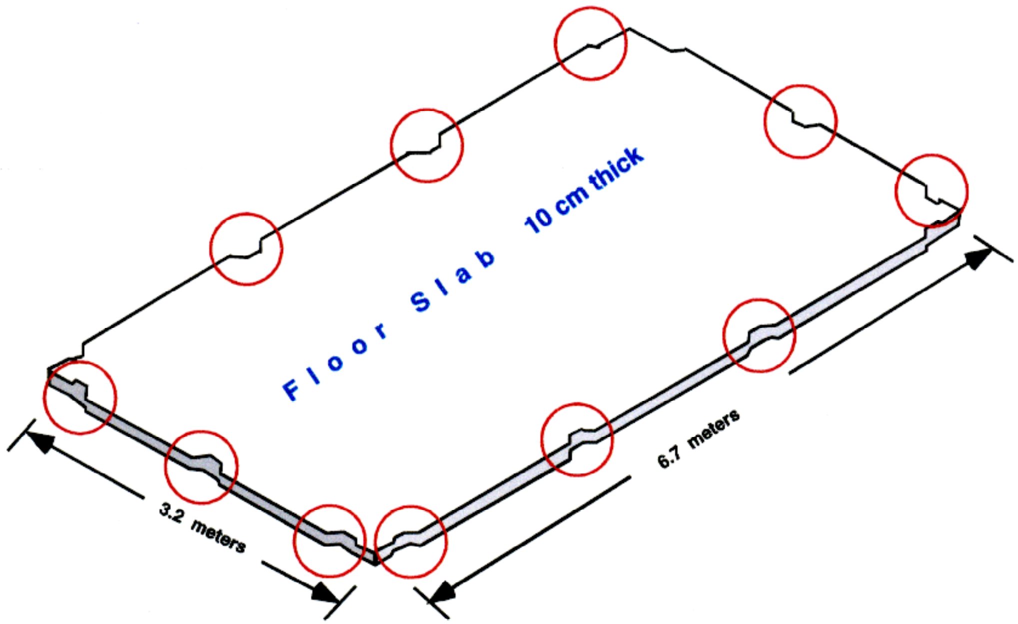
Floor/Ceilings and Dimensions

Commentary

Panels used to serve as both ceilings and floors are made of concrete poured around a steel mesh frame, placed in the middle of a 10 cm thick slab that measures 3.2 by 6.7 meters, and then transported to the construction site.

Strength is 305 kg/cm^2.

Reinforcement bar connections are placed into the concrete during the process, the ends project on sides and end of slab.



Location of steel hoop connections. Hoops in wall and floor panels are welded to counterparts in walls and mortar is then poured around connection.

Figure 144. Mass 22-4-c construction.

Mass 22-4-d Construction

Box-Wall Principle Apartment Building

Walls and Dimensions

Commentary

Panels are concrete, reinforced with a steel mesh grid (with 20 cm spacing), and measure —in this example — 2.4 x 6.6 meters. As with the floor/ceilings, rebar extends outward from the panel at the connection points, allowing them to be tied to counterparts for welding and mortaring.

Strength is 326 kg/cm^2.

As with the floor/ceilings, they are built in a factory and transported to the building site for assembly.

Wall Panel

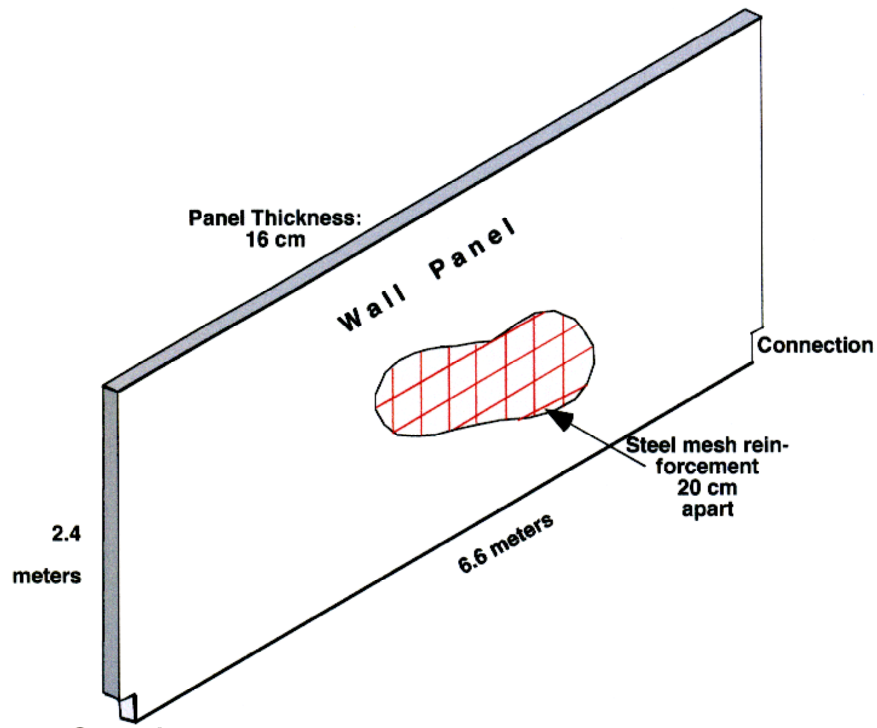


Figure 145. Mass 22-4-d construction.

Mass 22-5 Locale

Box-Wall Principle Apartment Building

Commentary

State planning is clearly manifested in apartment developments of this sort. The Soviets used this form widely and is common in countries under their domination but it is also seen in many parts of the western world, especially in Europe. The form provides shelter and open spaces between and among the buildings.

Complex of Box-Wall Apartment Buildings, Prague, Czech Republic (Typical UTZ Do2)

RE photo 2004

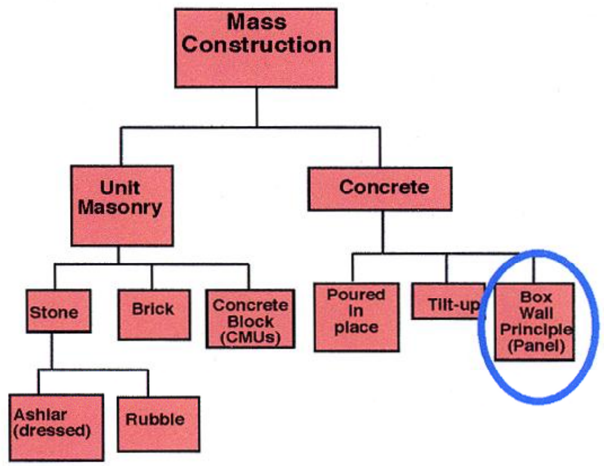
Developments of this type were replicated countless times in the Soviet Union and the Warsaw Pact to replace housing lost during WW II. Their construction followed state-directed plans expressed in buildings in the five story range (and without elevators). Entrances and stairways served a set of units on each side of each stair complex. Ventilation (see rooftops) was also by sets of units.

Figure 146. Mass 22-5 locale.

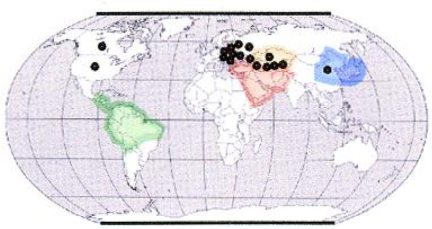
Mass 23-1 Place on Building Construction Chart

Box-Wall Principle (Panel Wall) Construction Hotel

Place on Building Construction Chart



World locations where Box Wall/ Panel Buildings are Important



International Example

RE photo.

This box-wall principle type of hotel structure has been replicated widely. The photo clearly shows the seven upper floors to be a series of "boxes" supporting each other. The elevator module is off-centered in order to have access from the hotel lobby. The ground floor is devoted to public room use. This form of construction is particularly well suited to hotel use considering that each guest room (plus interior bath) is a single cell and with walls that are both sound proof and not meant to be modified to serve other uses.

Figure 147. Mass 23-1 place on building construction chart.

Mass 23-2 Elevations

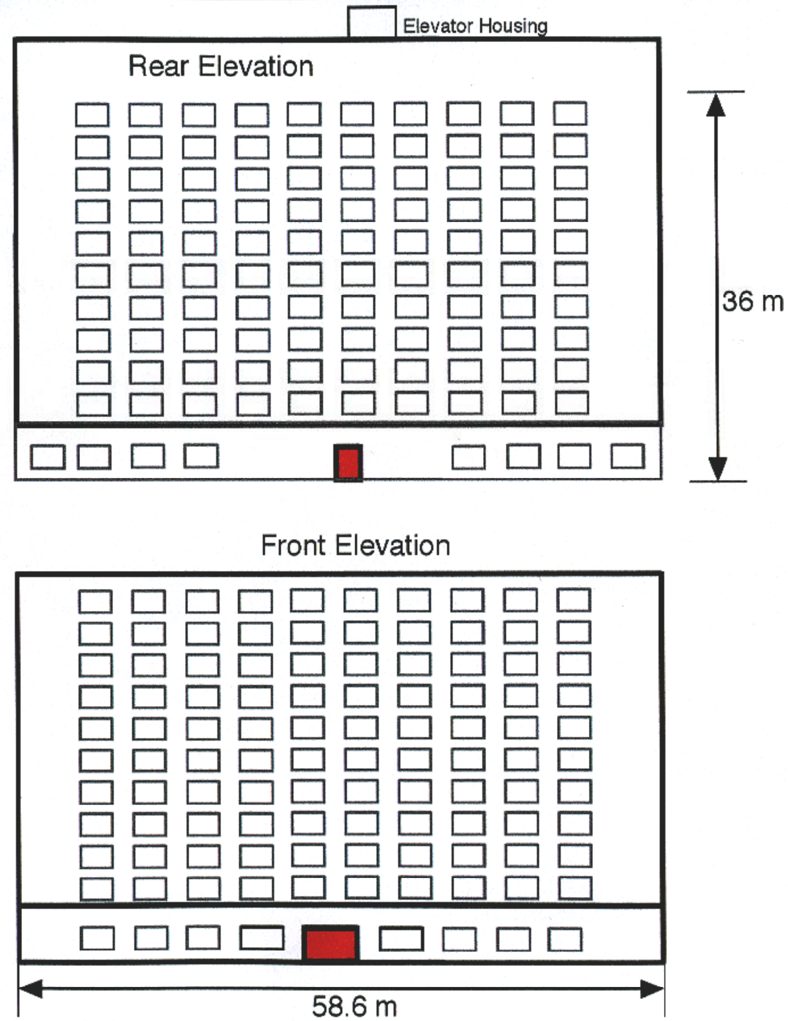
Box-Wall Principle (Panel Wall) Hotel, Elevations	
Commentary Front elevation shows the main entrance and large windows for the lobby/reception area. The rear elevation shows the rear door and additional guest rooms on the ground floor. The elevator housing shows from this side.	

Figure 148. Mass 23-2 elevations.

Mass 23-3-a Floor Plan

Box-Wall Principle (Panel Wall) Hotel, Floor Plans

Commentary

Guest rooms are on the upper floors, plus a few on the ground floor. Public areas, the reception, lobby, services, etc. are on the ground floor.

The main entrance is in the center of the building; Other entrances are at the rear and the ends of the building.

Stairs are placed at both ends of the building.

See following plates for details on dimensions of the guest rooms.

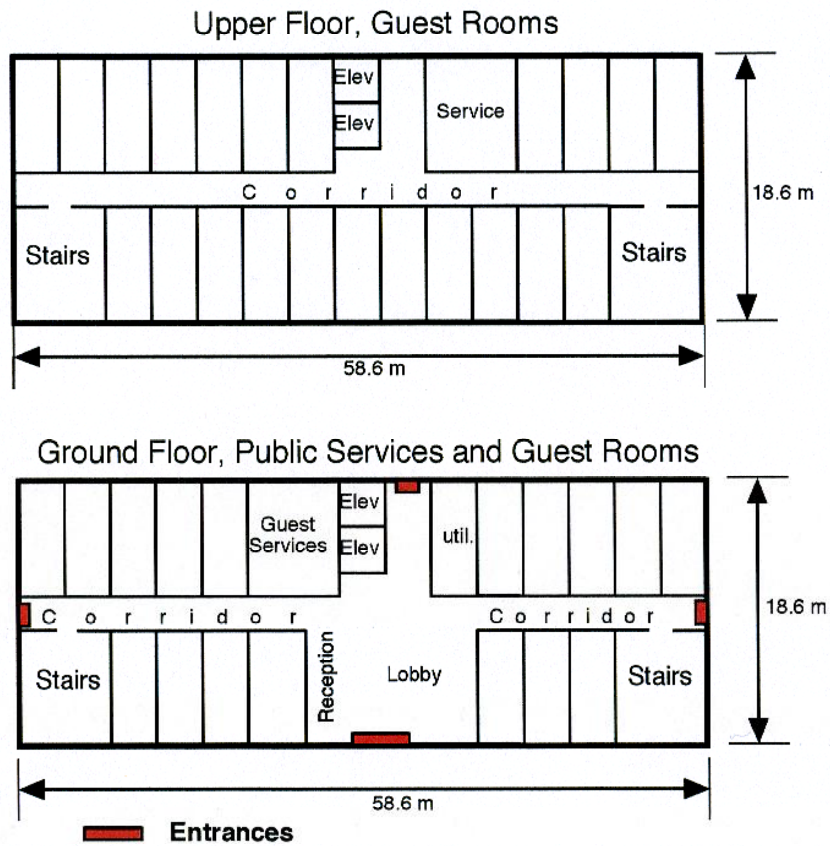


Figure 149. Mass 23-3-a floor plan.

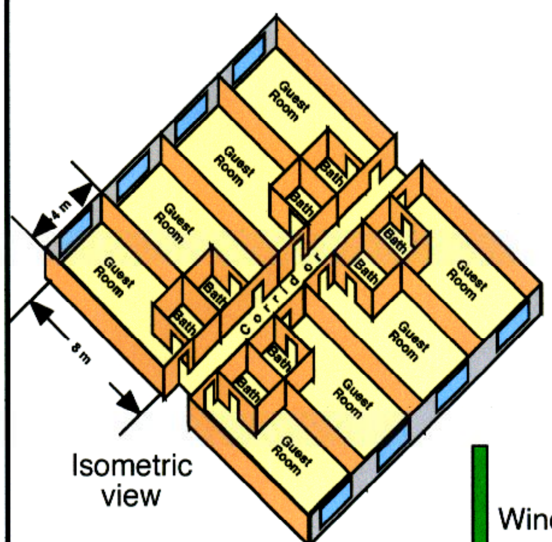
Mass 23-3-b Floor Plan

Box-Wall Principle (Panel Wall) Construction Hotel

Floor Plan of a Segment of a Guest Room Floor

Commentary

This segment of a guest room floor of a box-wall principle (panel wall) hotel represents all guest rooms, standard on each floor. Room size is about 4 x 8 meters; virtually all of the outer wall is window. A corridor runs through the center of the building. Connecting doors between rooms are often present.



Isometric view

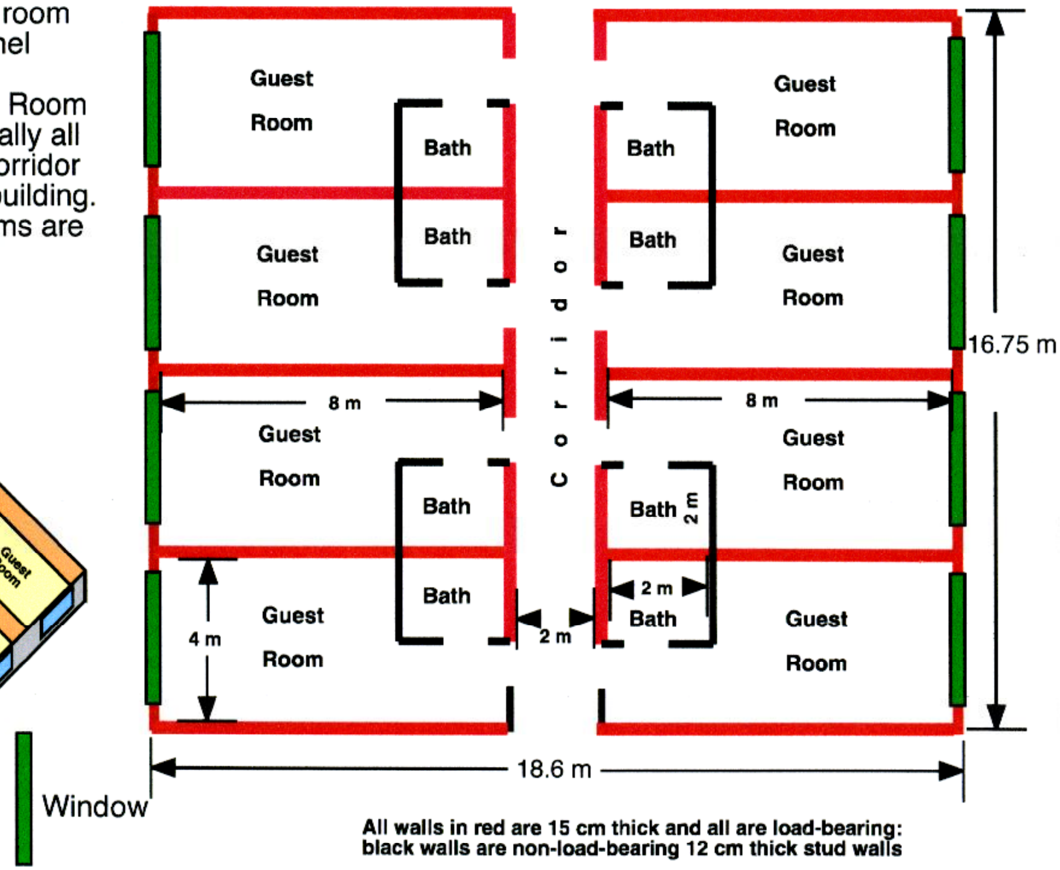


Figure 150. Mass 23-3-b floor plan.

Mass 23-4 Construction Details

Box-Wall Principle (Panel Wall) Construction Hotel

Commentary

The mass nature of construction is clear in this example. The side, bottom, top, and rear walls form a closed box of reinforced concrete (15 cm in thickness). The end wall is open, with much of its area being devoted to a large window, the only ventilation and light for each cell. Some light partition material is used for the small part of the end wall not devoted to the window.

Box-wall Building Under Construction

RE Photo

Figure 151. Mass 23-4 construction details.

Table 18. Framed urban terrain building types.

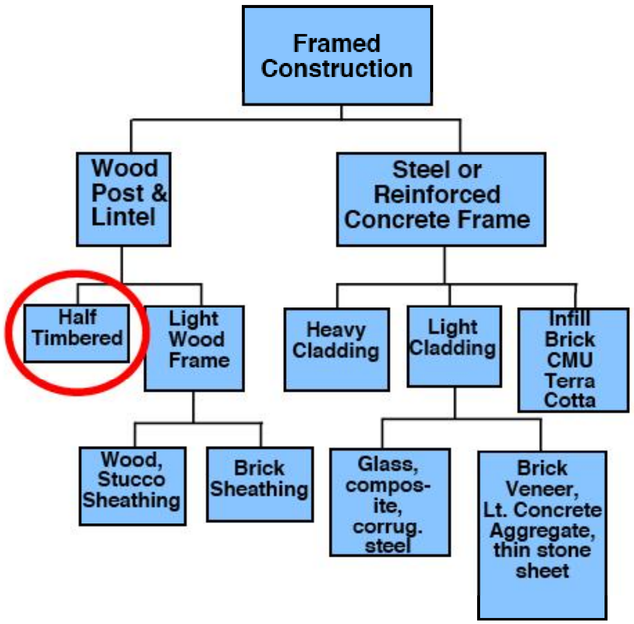
Twenty-One Urban Terrain Building Types			
Building Type	**Number of Plates**	**Building Type Name**	**Building Material**
Framed 1	5	Half-timbered post and lintel house	Wood framed
Framed 2	6	Half-timbered store with residence above	Wood framed
Framed 3	7	Wood-framed one-story house	Wood framed/wood
Framed 4	5	Wood-framed house with brick veneer cover	Wood framed/brick
Framed 5	5	Wood-framed store	Wood framed/wood
Framed 6	9	Steel-framed heavy-clad hotel	Steel framed
Framed 7	10	Steel-framed heavy-clad office building	Steel framed
Framed 8	5	R/C-framed light-clad apartment building	Steel/R/C framed
Framed 9	9	R/C-framed light-clad hotel	Steel/R/C framed
Framed 10	6	R/C-framed light-clad office building	Steel/R/C framed
Framed 11	7	Central pylon with light-clad steel frame office	Steel/R/C framed
Framed 12	12	R/C-framed house with brick infill walls	R/C framed with brick
Framed 13	8	R/C-framed house with terra cotta infill walls	R/C framed with terra cotta
Framed 14	8	R/C-framed CMU infill store/apartment building	R/C framed with CMU
Framed 15	5	R/C-framed with brick infill walls store/office	R/C framed with brick
Framed 16	7	R/C-framed CMU infill industrial/storage building	R/C framed with CMU
Framed 17	6	R/C-framed terra cotta infill industrial/storage	R/C framed with terra cotta
Framed 18	6	R/C-framed brick infill industrial/storage building	R/C framed with brick
Framed 19	6	R/C-framed school with brick veneer over infill	R/C framed with brick
Framed 20	5	Steel-framed light cladding industrial/storage	Steel framed with steel
Framed 21	5	Steel-framed double light cladding industrial storage	Steel framed with steel
Total plates: 142			

Note: R/C = reinforced concrete. CMU = concrete masonry unit.

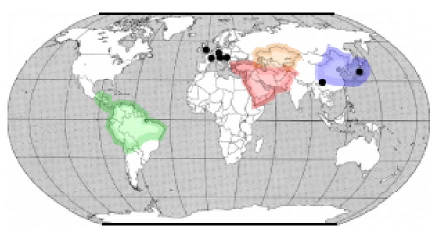
Framed 1-1 Place on Building Construction Chart

Half-timbered Post and Lintel Construction House

Place on Building Construction Chart



World locations where half-timbered buildings are important



International Example

RE photo.

An example of half-timbered construction houses extant in Europe (this one in a former agricultural village in Germany).

Short timbers were braced against each other to form a post and lintel frame. Before the advent of power saws these timbers were hand hewn (some still show adze markings). Space between timbers was filled with wattle. Being a frame, and not a mass construction wall, win-dows did not have to be aligned vertically.

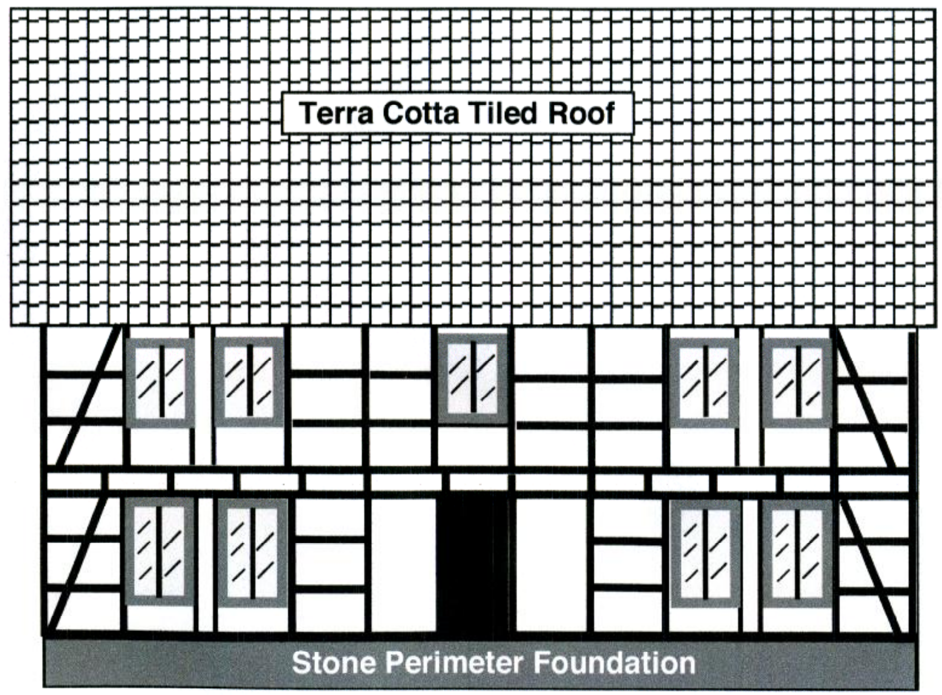
Figure 152. Framed 1-1 place on building construction chart.

Framed 1-2 Elevation and Construction Description

Half-timbered Post and Lintel Construction House

Commentary

In this type of construction, hewn timbers were used as frame members in a way similar to that employed today by reinforced concrete or steel columns and beams. Because of the difficulty of forming long columns and beams, builders — not having powered circular saws — were forced to hew square timbers from logs using a hand adze as the principal tool. Short pieces were used then to strengthen the structure; signature diagonal braces complete the image of this type of construction. Non-load-bearing fill (called wattle and daub) was placed between frame members. See plate Framed 1-4 for details.



Windows are placed between posts and beams in the same fashion as windows are placed in modern framed structures.

Figure 153. Framed 1-2 elevation and construction description.

Framed 1-3-a Floor Plan and Structure

Half-timbered Post and Lintel Construction House

Commentary

Just as with modern high-rise framed office buildings, room configuration in post and beam houses can be open in nature as it is not bound by location of load-bearing walls; simple partitions between rooms suffice. These partitions are located in alignment with the beams above them (for the ground floor), as in the example. Windows and doors are limited in width by the narrow spaces between columns.

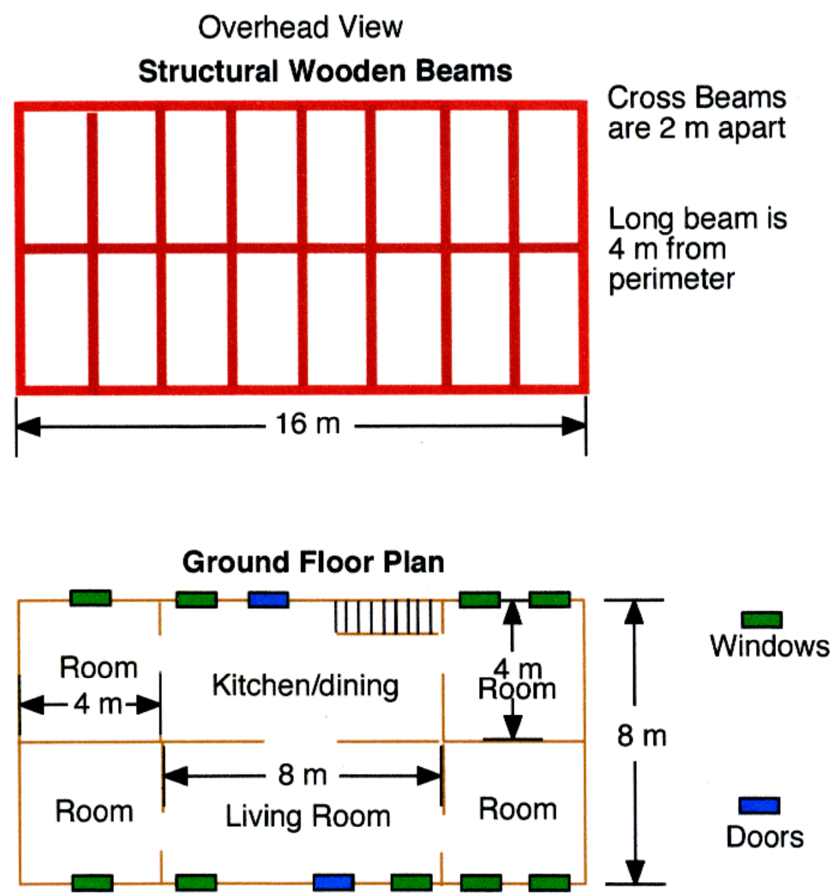


Figure 154. Framed 1-3-a floor plan and structure.

Framed 1-4 Construction

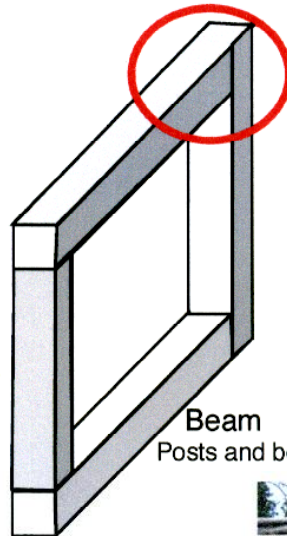
Half-timbered Post and Lintel Construction House

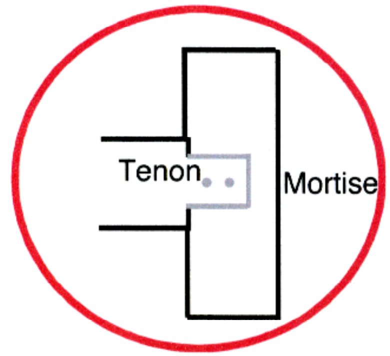
Construction Details

Commentary

Half-timbered structures employ hewn timbers in the form of posts and beams to form a skeleton frame. Connections are made by forming tenons and inserting these into mortises to form a joint. This joint is then anchored with dowels. The red circled example of one joint is representative of all joints.

Space between the posts and beams is taken up, in a traditional fashion, with non-load-bearing wattle and daub (the wattles are wooden poles, held together with a clay daub); the surface was usually whitewashed resulting in a highly contrasting dark wood with white wall in between. The wall is a non-load-bearing infill wall, performing the same function as an infill wall between r/c or steel does in framed structures.





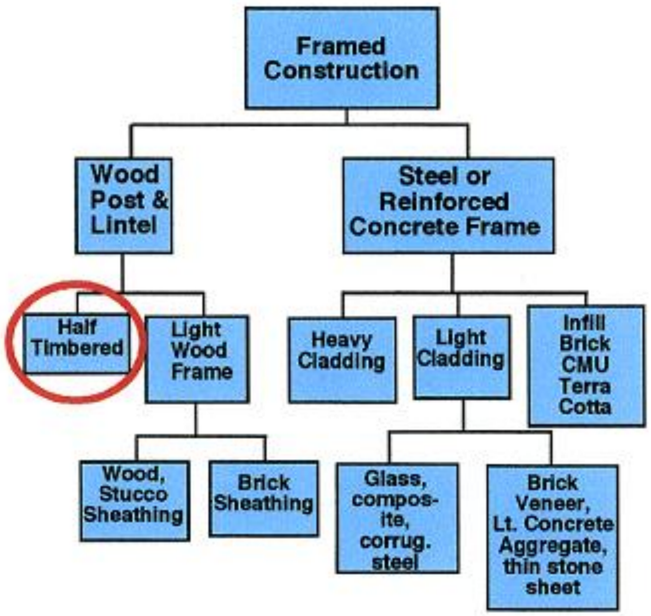
Wattle and daub infill 15 cm thick

Figure 155. Framed 1-4 construction.

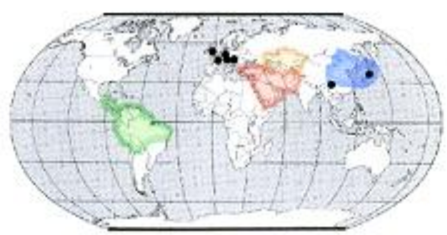
Framed 2-1 Place on Building Construction Chart

Half-timbered Store with Residence Above

Place on Building Construction Chart



World locations where half-timbered buildings are important



International Example

RE photo.

These stores, in Germany, (with residences on the upper floors) have modern storefronts along the street but the old structure of traditional post and lintel buildings. As with modern steel or r/c framed structures, these wooden frames bear the weight and can have large window areas without losing support integrity.

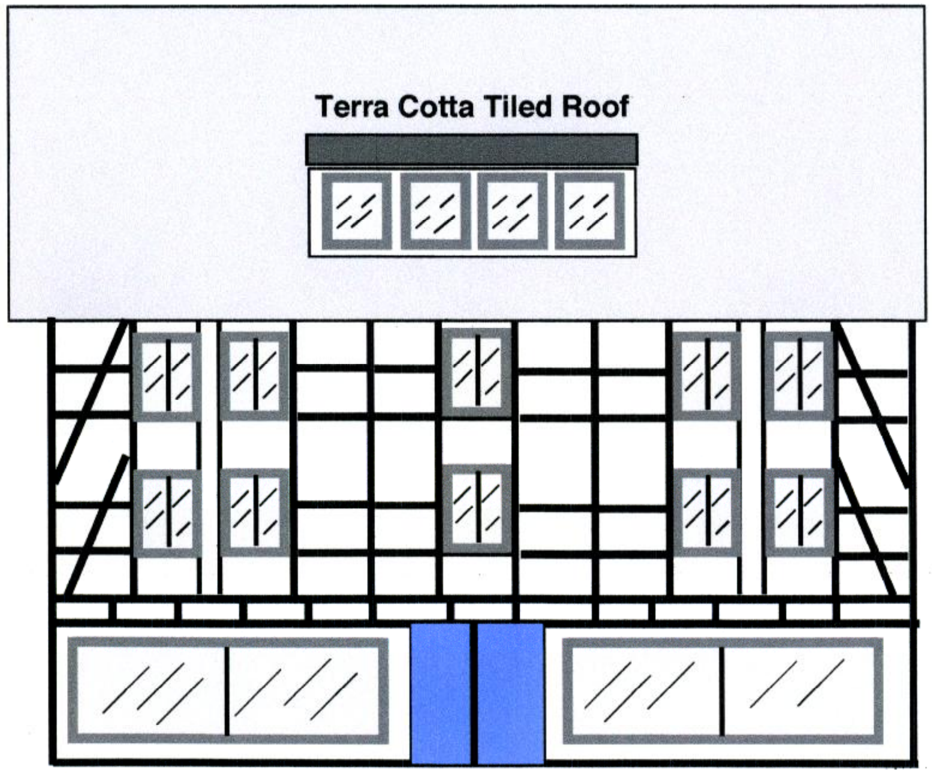
Figure 156. Framed 2-1 place on building construction chart.

Framed 2-2 Elevation and Construction Description

Half-timbered Store with Residence Above

Commentary

In this type of construction, hewn timbers were used as frame members in a way similar to that employed today by reinforced concrete or steel columns and beams. Because of the difficulty of forming long columns and beams, builders, not having powered circular saws, were forced to hew square timbers from logs using a hand adze as the principal tool. Short pieces were then used to strengthen the structure; signature diagonal braces complete the image of this type of construction. Non-load-bearing fill (called wattle and daub) was placed between frame members. See plate 2-4-a and b for details.



Windows are placed between posts and beams in the same fashion as windows are placed in modern framed structures.

Figure 157. Framed 2-2 elevation and construction description.

Framed 2-3-a Floor Plan

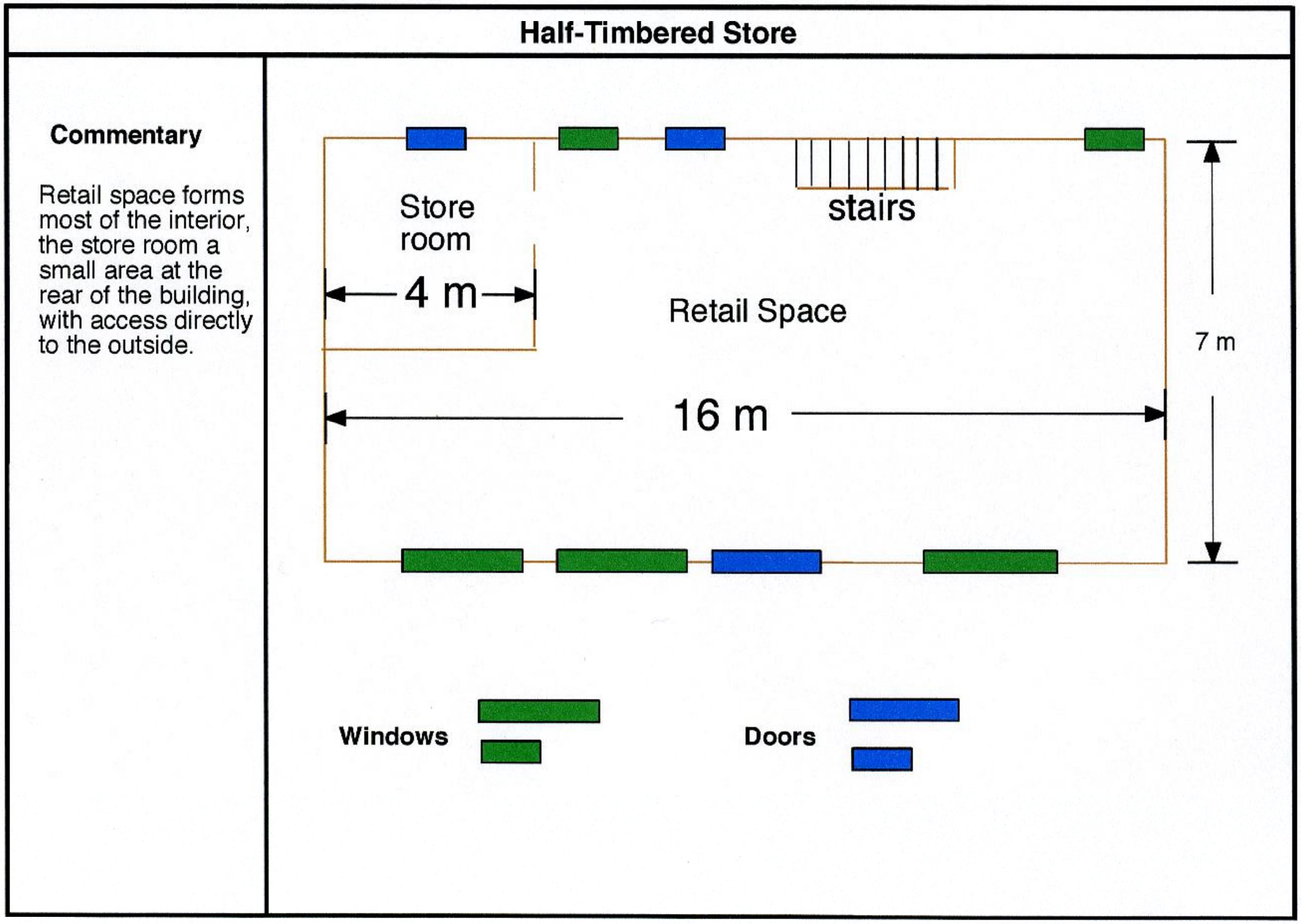


Figure 158. Framed 2-3-a floor plan.

Framed 2-4-a Construction Method

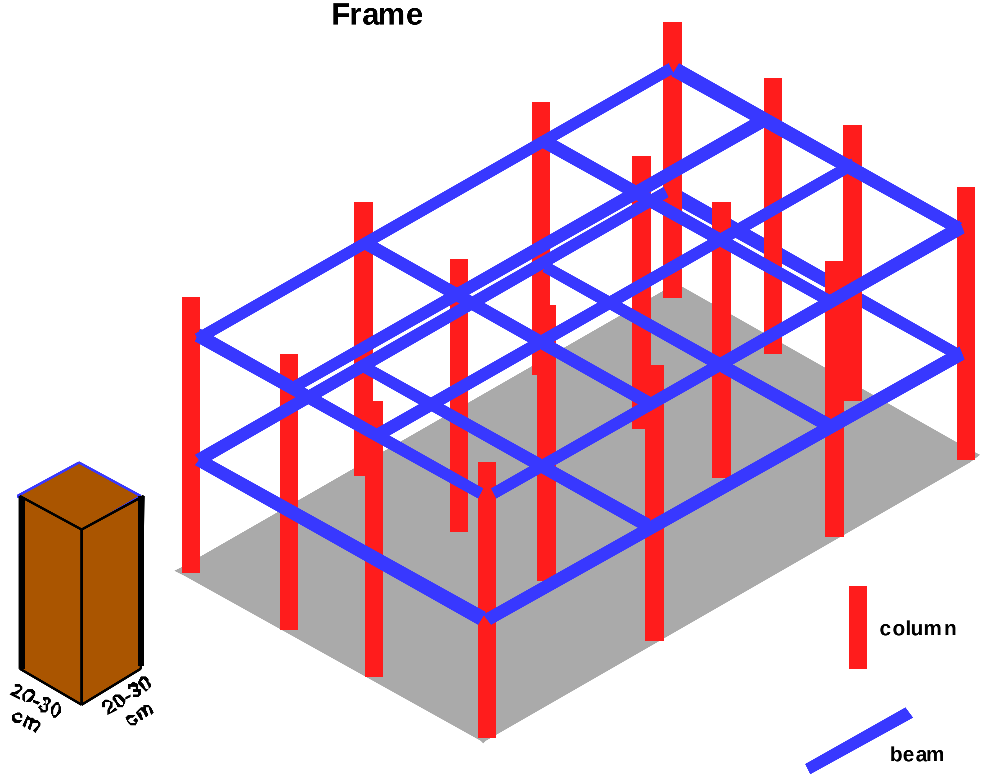
Half-timbered Store with Residence Above

Construction Method and Dimensions

Commentary

Half timbered buildings were the precursors to steel and r/c skeletal construction but with wooden timbers. The frame bore the loads and not the walls. Timbers were massive (20 to 30 cm on a side) hewn from single logs with adzes. Connections were made with tenons and mortises. See following plate.

Frame



Windows are placed between posts and beams in the same fashion as windows are placed in modern framed structures.

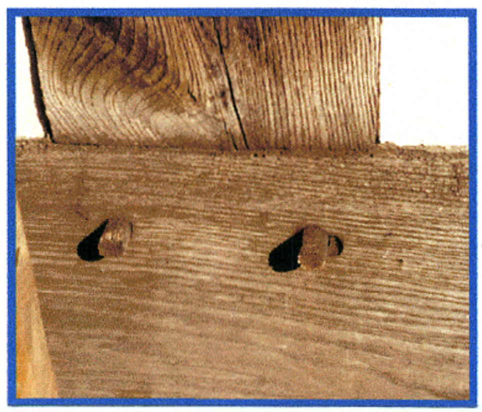
Figure 159. Framed 2-4-a construction method.

Framed 2-4-b Construction Details

Half-timbered Store with Residence Above

Post and lintel house in a village in southern China. *RE photo.*

Purlins and truss of the house to the left. The vertical beam is mortised on to the purlin. *RE photo.*



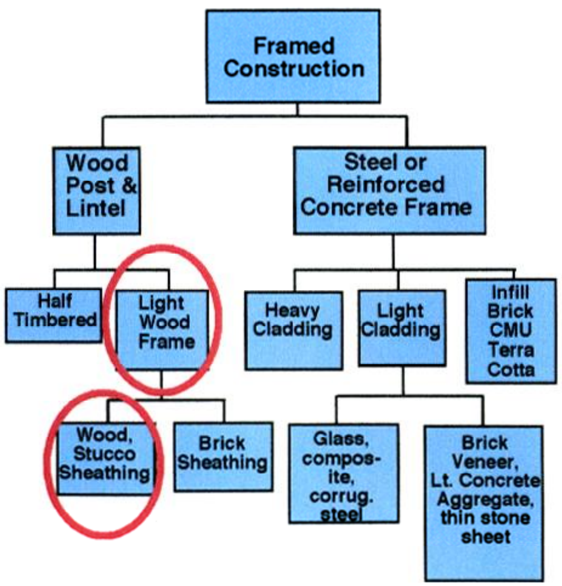
Dowels fix tenon to mortise in this example in the UK. *RE photo.*

Figure 160. Framed 2-4-b construction details.

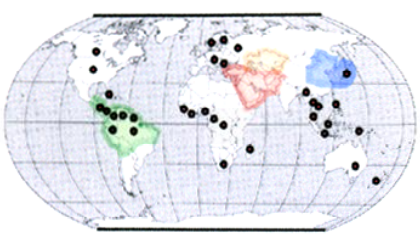
Framed 3-1 Place on Building Construction Chart

Wood Framed One Story House

Place on Building Construction Chart



World locations where wood framed buildings are important



International Example

Wood framed house with wood siding. Sydney, Australia. *RE photo.*

Wood is often used for constructing frames and for exterior siding for houses in countries where construction wood is commonly available and inexpensive. This house in Sydney, Australia, looks much like houses in many parts of the United States where wood is widely used. The siding is in ship lap form placed horizontally on the studs of the frame, usually over a layer of insulation. The frame is balloon construction (narrowly spaced studs), rather than the older form of post and beam frame construction.

Figure 161. Framed 3-1 place on building construction chart.

Framed 3-2 Elevations

Wood Framed One Story House

Front, Rear, and Side Elevations

Commentary

Elevations of this representative single family wood framed house reflect the floor plan (see floor plan). Windows are larger for the living room and dining room, smaller for the kitchen and the bedrooms.

Treatments of the outer walls (wooden siding, stucco, and brick) are shown in separate panels.

Elevations

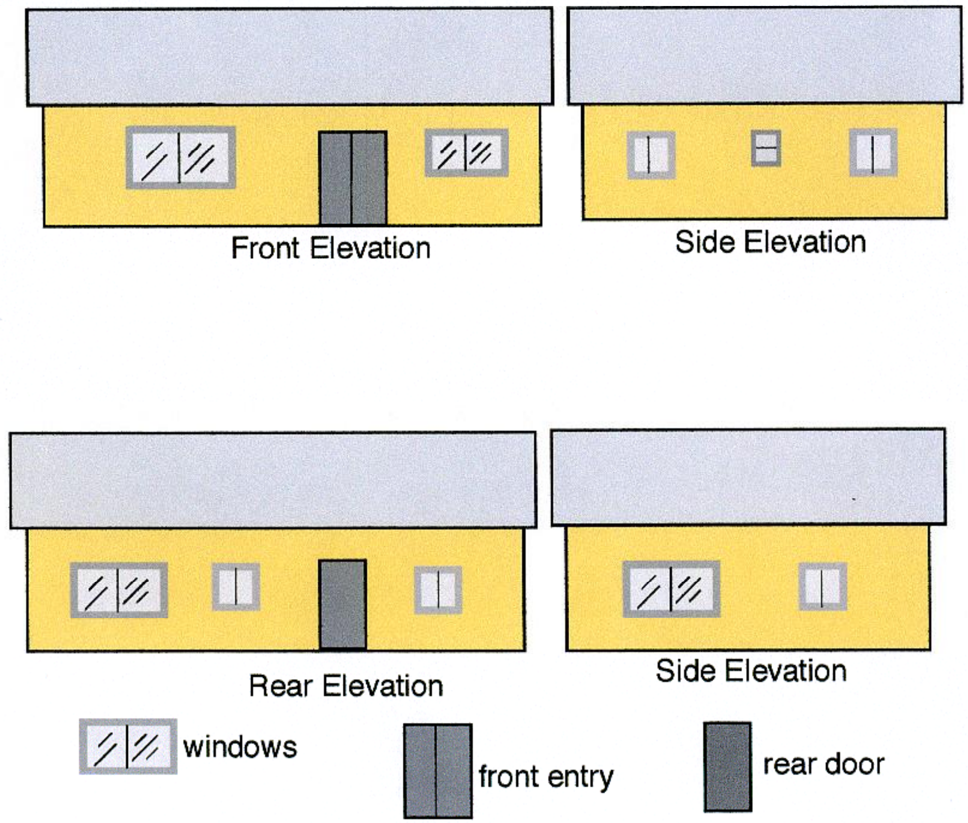


Figure 162. Framed 3-2 elevations.

Framed 3-3-a Floor Plan

Wood Framed One Story House

Commentary

This simple floor plan is intended to represent the great number of detached, single-family houses so common in the world. It is the archetype of what has traditionally been called a five room house. Its rooms serve the basic functions: living areas, dining, food preparation, sanitation, and sleeping. Room sizes are common and are human scaled, e.g., a 9 square meter bedroom is just large enough for a bed and furnishings. The kitchen's size is sufficient to contain sink, stove, refrigeration, and table. The large space for the entry also includes a small closet. The entry doorway is wider than that of the rear door.

Floor Plan

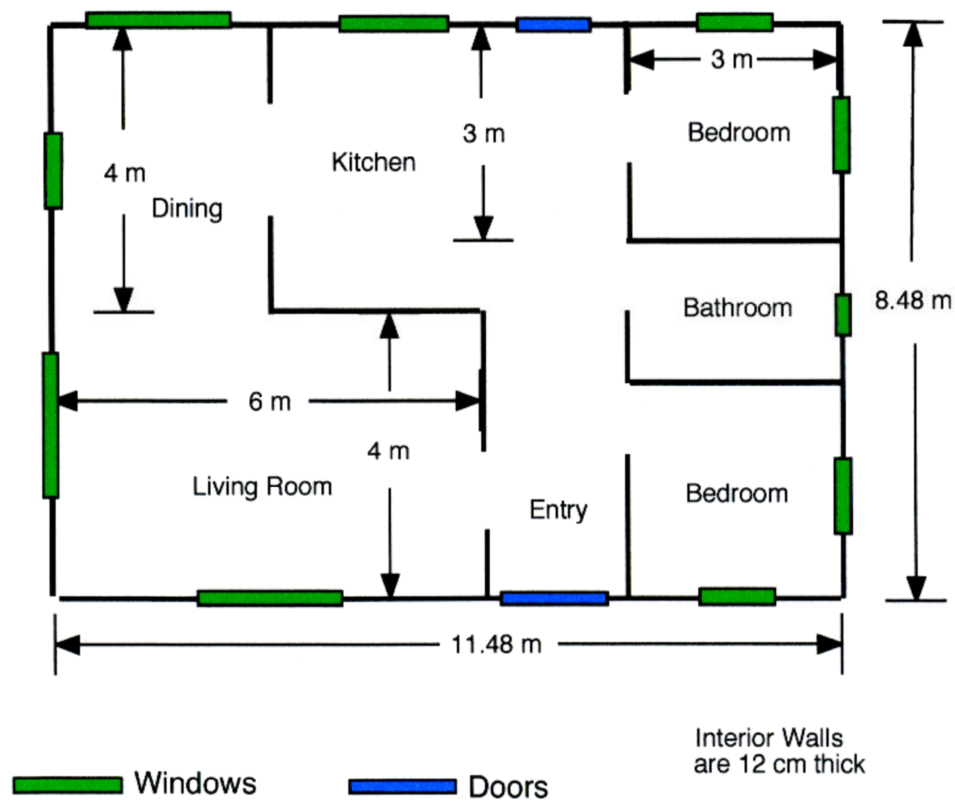


Figure 163. Framed 3-3-a floor plan.

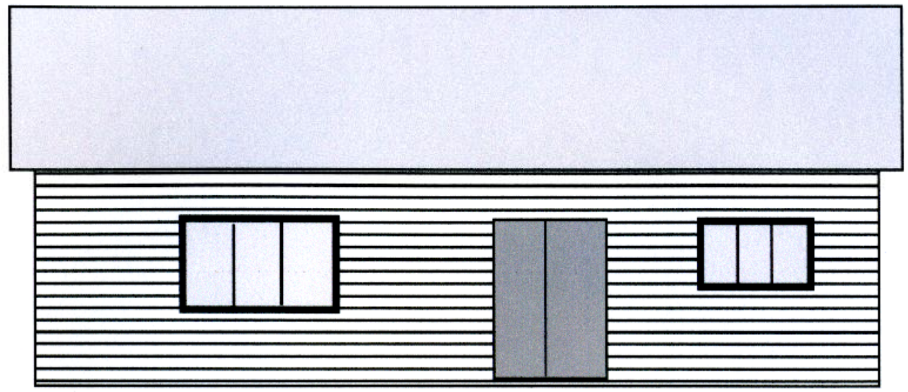
Framed 3-4-a Construction

Wood Framed One Story House

Wood Siding Covering Balloon Construction

Commentary

Here, horizontal board siding covers first a stiffening layer (plywood or some composite material) and the wooden studs of balloon construction.



Front Elevation

Separation (centers to centers) varies; US standard is 16"

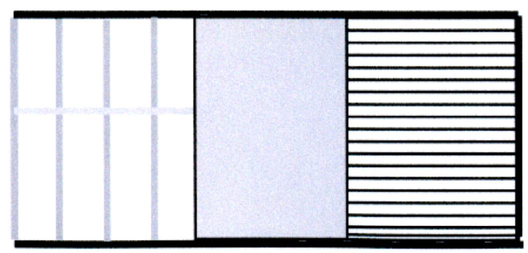


Figure 164. Framed 3-4-a construction.

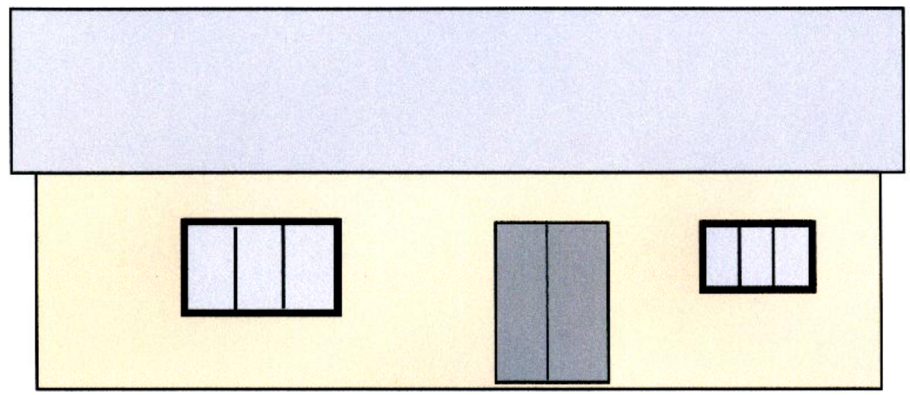
Framed 3-4-b Construction

Wood Framed One Story House

Stucco Covering Balloon Construction

Commentary

Here, stucco covers first a stiffening layer (plywood or some composite material) and the wooden studs of balloon construction. The stucco serves to protect against the elements; the stucco layer is usually two to three centimeters thick.



Front Elevation

Separation (centers to centers) varies; US standard is 16"

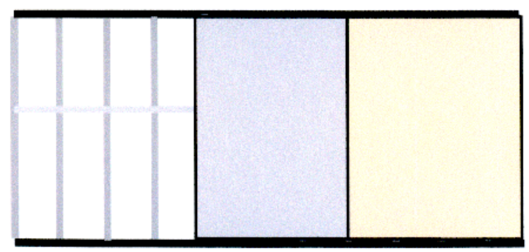


Figure 165. Framed 3-4-b construction.

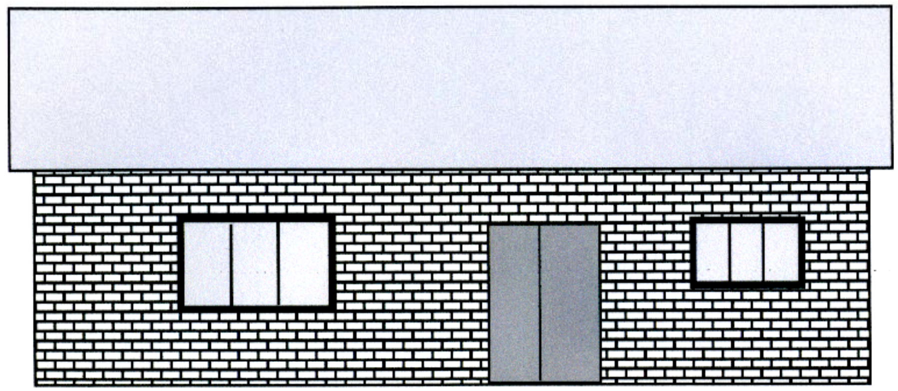
Framed 3-4-c Construction

Wood Framed One Story House

Brick Covering Balloon Construction

Commentary

Here, brick covers first a stiffening layer (plywood or some composite material) and the wooden studs of balloon construction. The brick layer protects against the elements; it is 11.5 cm thick.



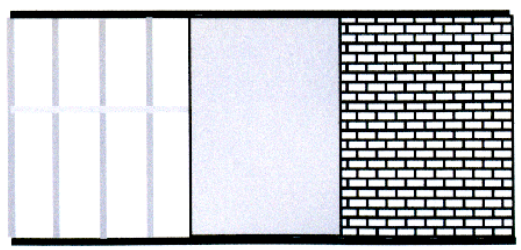
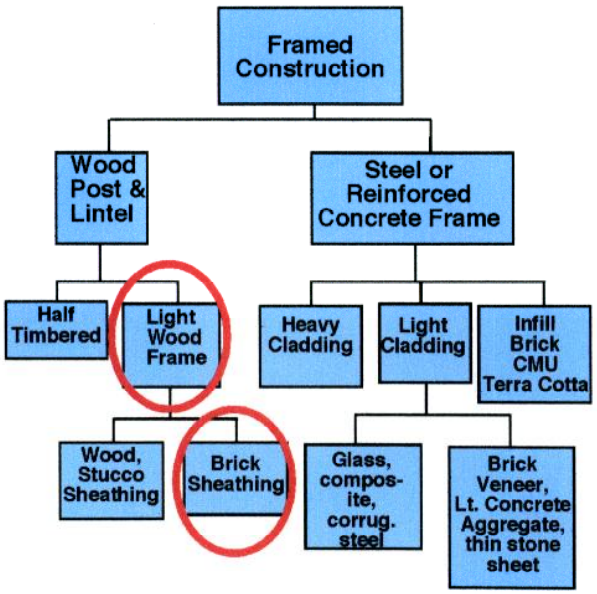


Figure 166. Framed 3-4-c construction.

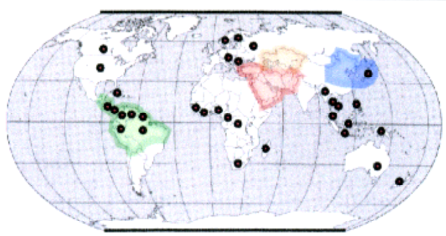
Framed 4-1 Place on Building Construction Chart

Wood-framed House with Brick Veneer Cover

Place on Building Construction Chart



World locations where wood framed buildings are important



International Example

Partially brick-veneered wood framed house, in New Zealand. *RE Photo*

A common practice with wood-framed structures is to place a non-load-bearing brick sheathing on all or a part of an exterior wall. As in this example, if only a partial cover of bricks is used, they will be on the ground floor only, following the tradition of a building having a strong foundation (pediment).

Figure 167. Framed 4-1 place on building construction chart.

Framed 4-2 Elevations

Wood-framed House with Brick Veneer Cover

Front, Rear, and Side Elevations

Commentary

Elevations of this representative single family wood framed house reflect the floor plan (see 4-3-a). Windows are larger for the living room and dining room, smaller for the kitchen and the bedrooms.

Treatments of the outer walls (wooden siding, stucco, and brick) are shown in separate panels.

Elevations

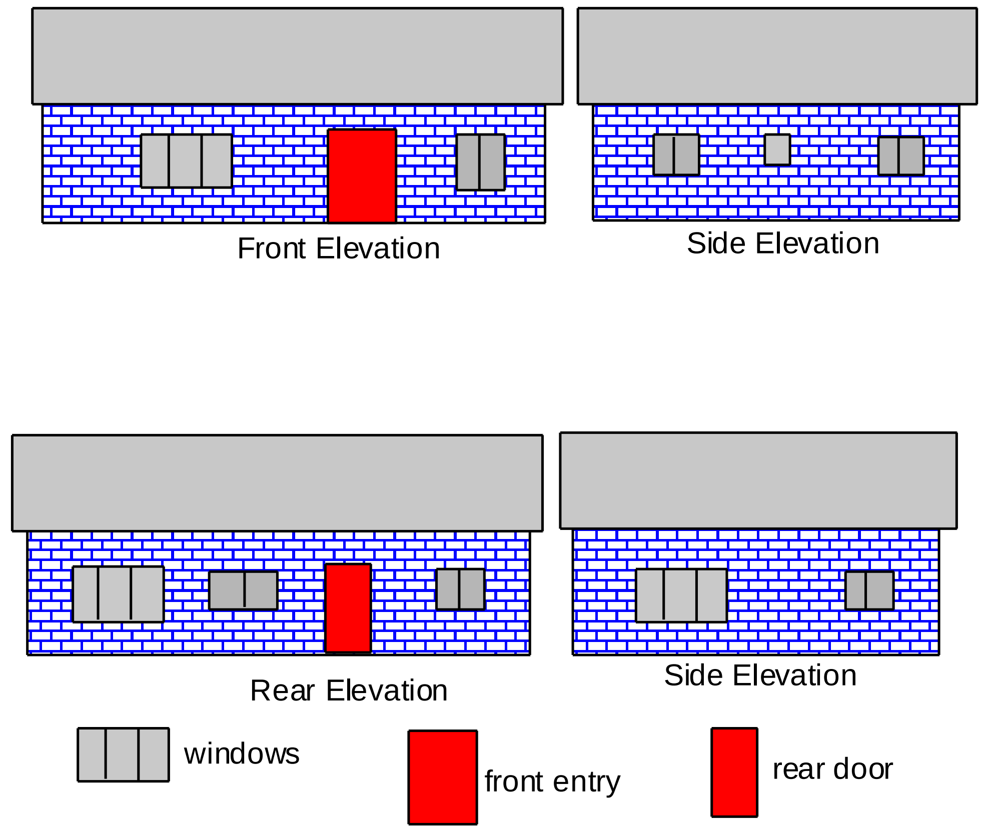


Figure 168. Framed 4-2 elevations.

Framed 4-3-a Floor Plan

Wood-framed House with Brick Veneer Cover

Commentary

This simple floor plan is intended to represent the great number of detached, single-family houses so common in the world. It is the archetype of what has traditionally been called a five room house. Its rooms serve the basic functions: living areas, dining, food preparation, sanitation, and sleeping. Room sizes are common and are human scaled, e.g., a 9 square meter bedroom is just large enough for a bed and furnishings. The kitchen's size is sufficient to contain sink, stove, refrigeration, and table. The large space for the entry also includes a small closet. The entry doorway is wider than that of the rear door.

Floor Plan

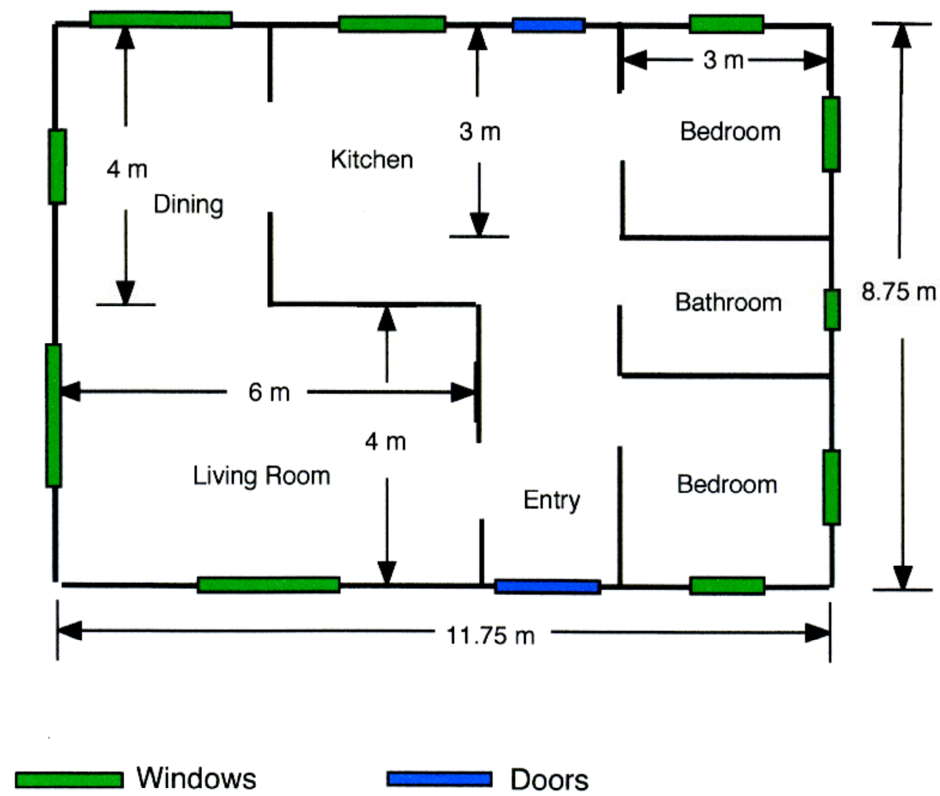


Figure 169. Framed 4-3-a floor plan.

Framed 4-4 Construction

Wood-framed House with Brick Veneer Cover

Commentary

Here, a brick layer covers first a stiffening layer (plywood or some composite material) and the wooden studs of balloon construction. The brick layer serves to protect against the elements. Exposed are the sides of stretchers, laid in what is called a facing pattern. The brick segment of the wall is 11.5 cm thick. Studs and stiffening (1 cm) add 12 cm for a total of 24 cm. This includes a 10 cm air space between the studs and a 1 cm covering on the interior side of the wall.

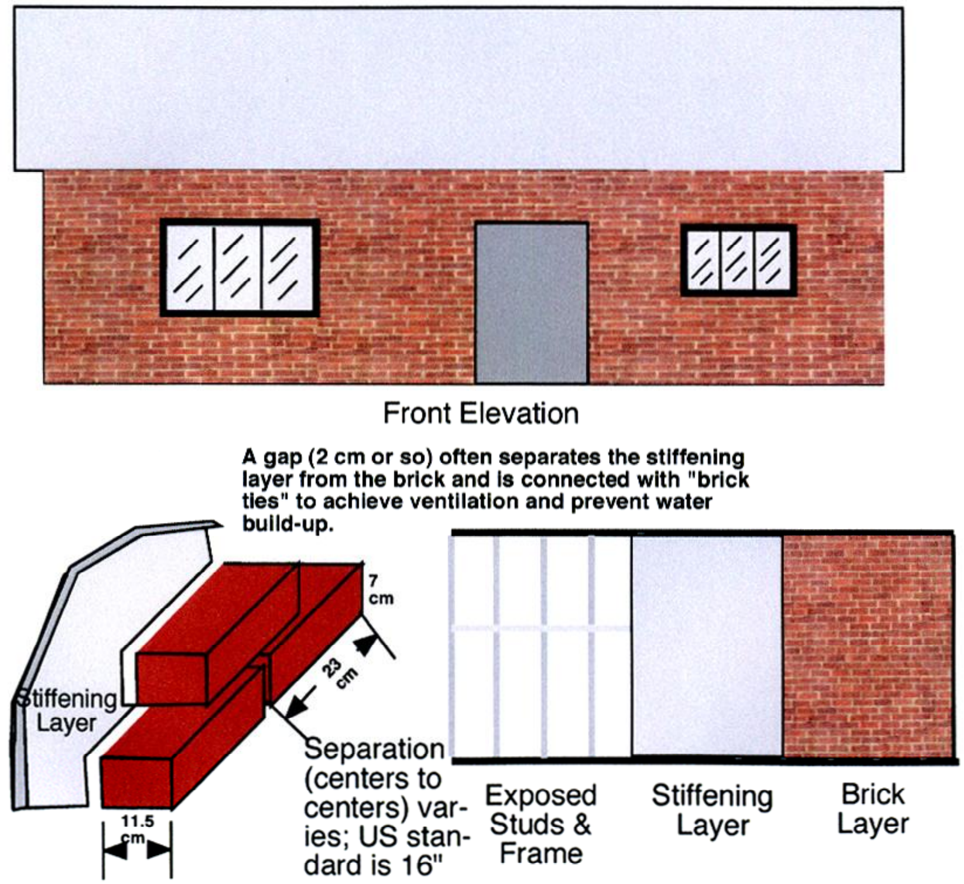


Figure 170. Framed 4-4 construction.

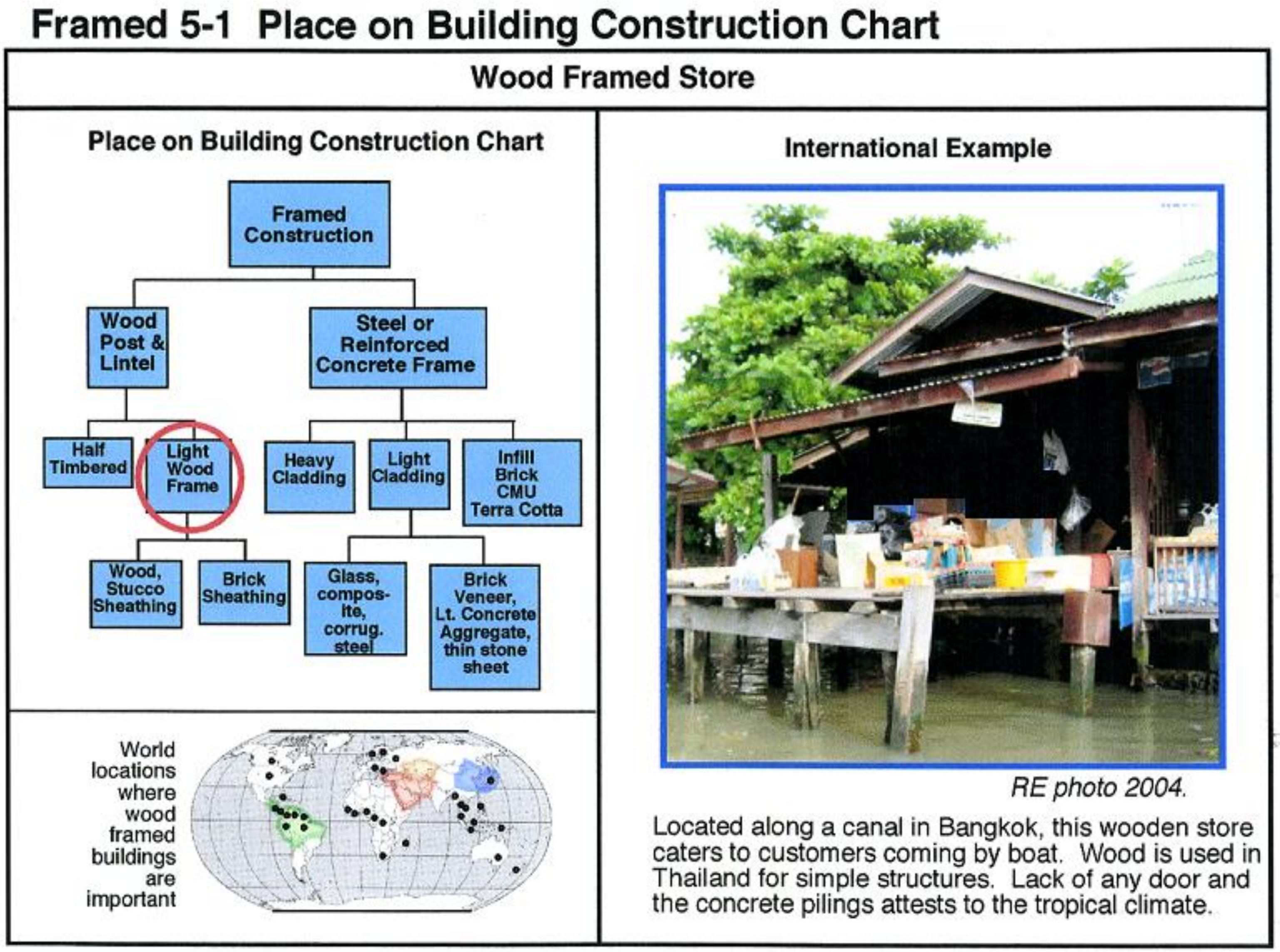


Figure 171. Framed 5-1 place on building construction chart.

Framed 5-2: Elevations

Wood-Framed Store

Front, Rear, and Side Elevations

Commentary

Stores of this type are virtually fully open on the front, or street (canal in this case) side, and have a smaller service door at the rear. Sides are solid (often abutting other stores on both sides.

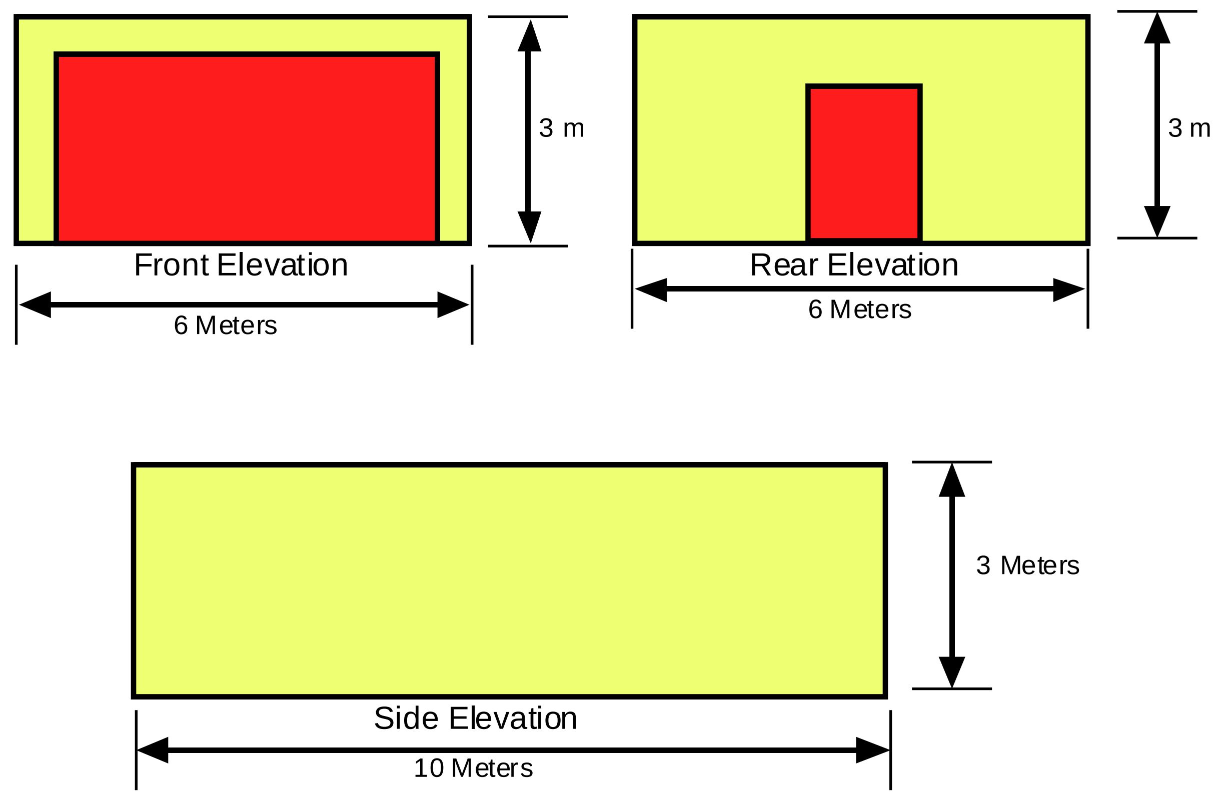
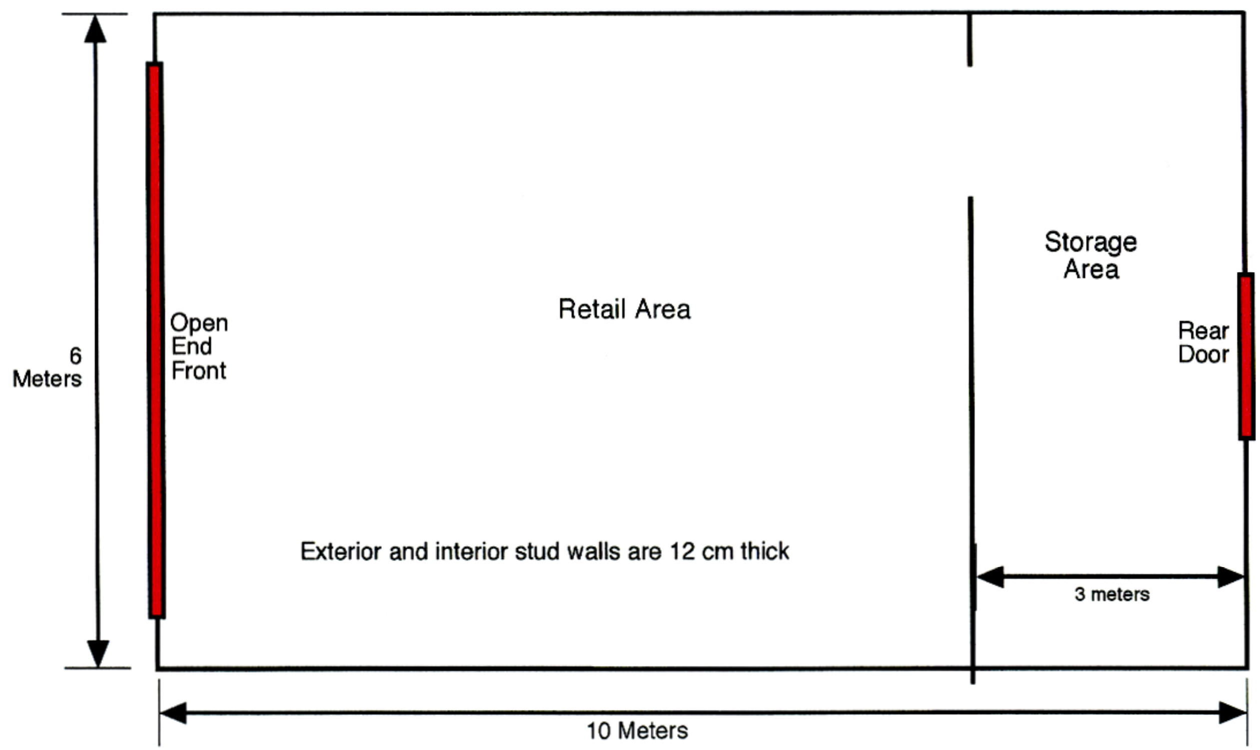


Figure 172. Framed 5-2 elevations.

Framed 5-3-a Floor Plan

Wood Framed Store



Commentary

Floor plans of small stores follow a simple pattern, namely a wide front open, especially in warm climate areas, as much storage area as the function of the store requires, leaving maximum space devoted to retail usage.

Figure 173. Framed 5-3-a floor plan.

Framed 5-4 Construction Method

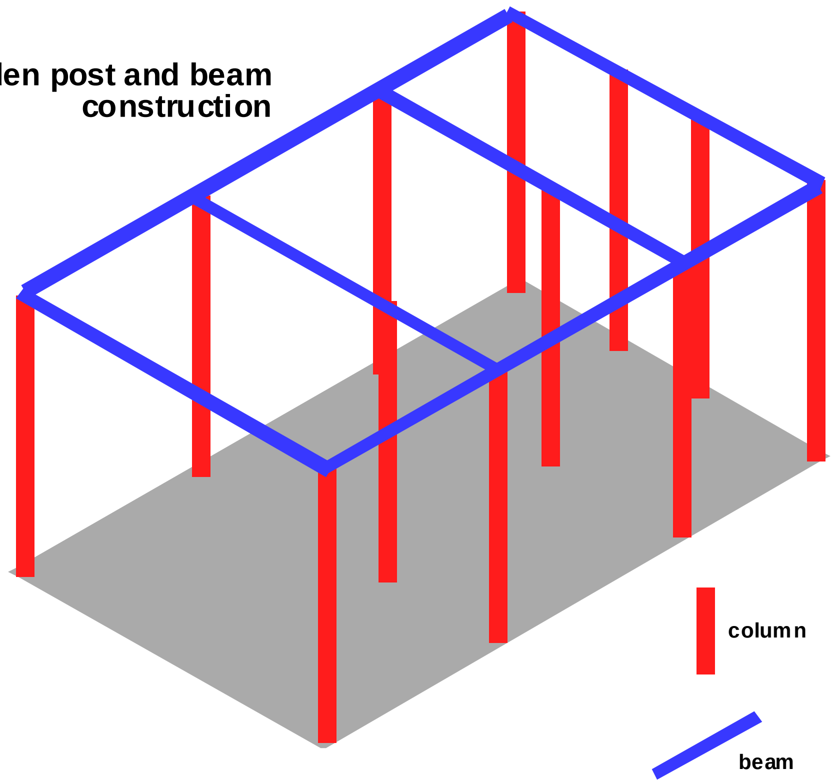
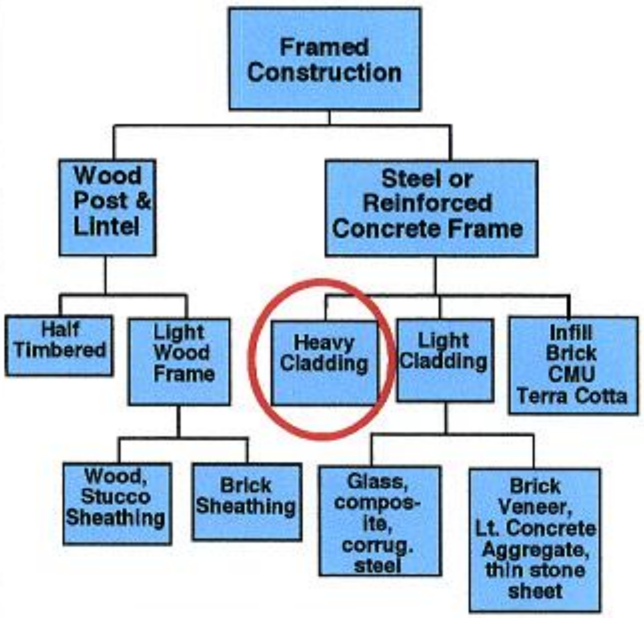
Light Wood-framed Store	
	Construction Method and Dimensions
Commentary This store uses the simplest form of wood frame. It is sufficient in a tropical environment where roof load is light and many walls are left open.	**Simple wooden post and beam construction**  Columns and beams are 15 cm x 15 cm

Figure 174. Framed 5-4 construction method.

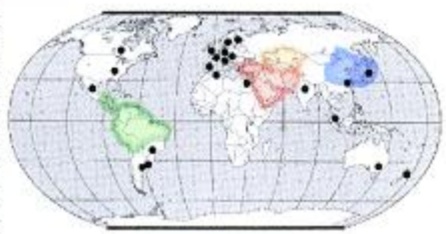
Framed 6-1 Place on Building Construction Chart

Steel-framed, Heavy Clad Hotel

Place on Building Construction Chart



World locations where Steel Framed Heavy clad Buildings are important



International Example

RE photo, 2004

A steel framed heavy-clad hotel in Kowloon (Hong Kong), built in the early part of the twentieth century, is a good example of the genre. It has a *pediment* on the ground floor with the usual shops, the *shaft* contains services on what the British refer to as the First Floor, guest rooms on the next four floors, and a *capital*, the top floor with suites and meeting rooms. The hotel's modern framed light-clad addition lies at the rear.

Figure 175. Framed 6-1 place on building construction chart.

Framed 6-2-a Elevation

Steel-framed, Heavy Clad Hotel

Commentary

The distinguishing feature of a steel-framed heavy-clad building is its masonry-like architecture. Heavy-clad structures — built in the period from 1885 to 1929 — used heavy ornamentation and classic form to match the appearances of the masonry (largely brick) structures which preceded them. The ground floor (the pediment) was ponderous with heavy molded terra cotta trim. The shaft had more of a uniform appearance using the same cladding material throughout. The capital employed a variation of the pediment with its heavy ornamentation (and often an overhanging cornice); it was the site for hotel suites, meeting rooms, and restaurants.

Front Elevation

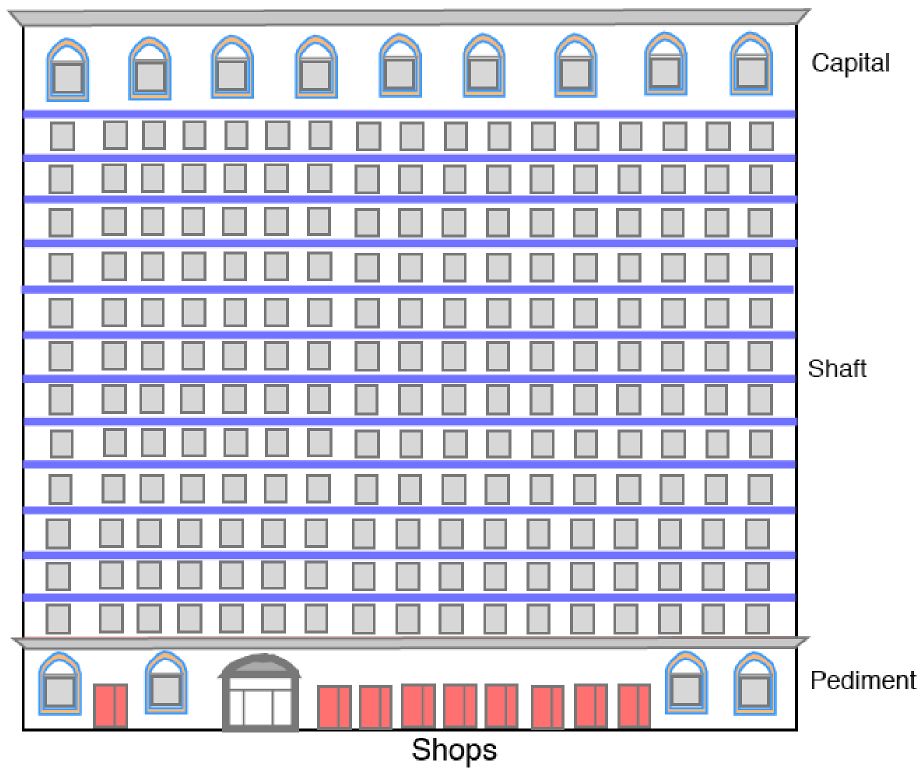


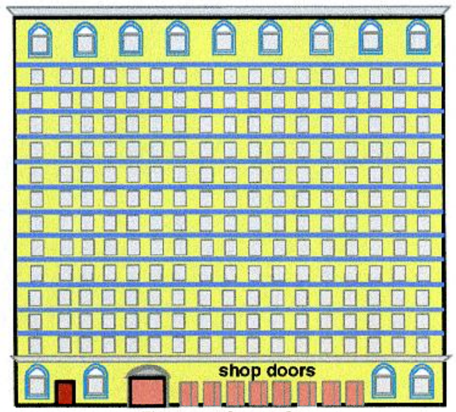
Figure 176. Framed 6-2-a elevation.

Framed 6-2-b Elevations

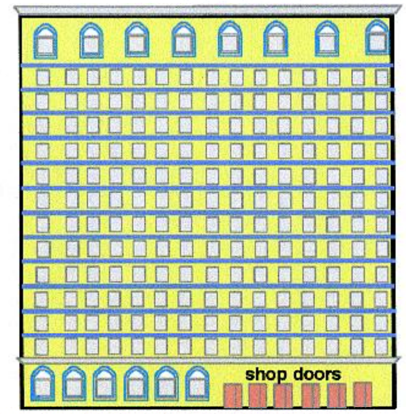
Steel-framed, Heavy Clad Hotel

Commentary

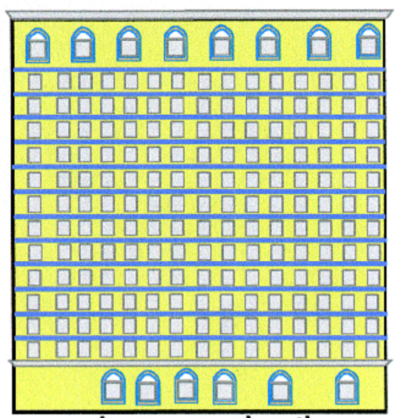
Venting patterns indicate the various functions within the hotel. The small windows in the shaft serve the guest rooms, the large windows at the capital vent public use rooms. Ground floor rooms are for public rooms and shops.



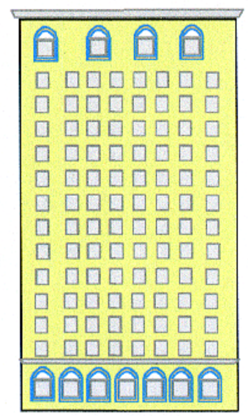
Front elevation



Long, side elevation



Long, rear elevation



Short, side elevation

Figure 177. Framed 6-2-b elevations.

Framed 6-3-a Floor Plan

Steel-framed, Heavy Clad Hotel

Commentary

The architectural device of using an L-shape is common at city block street corners. An L-shape permits the elements of the building to be narrow enough to access venting on both sides, and if the entire property is owned by the hotel, space in the rear can serve other uses, e.g., gardens, parking, etc. In response to high-value street frontage, the hotel will rent out narrow shops to purveyors of goods and services; the hotel requires but a narrow entrance (6 meters wide in this example) to provide entrance to hotel users. Restaurants and public meeting rooms are mainstays of ground floor occupance.

Ground Floor Plan

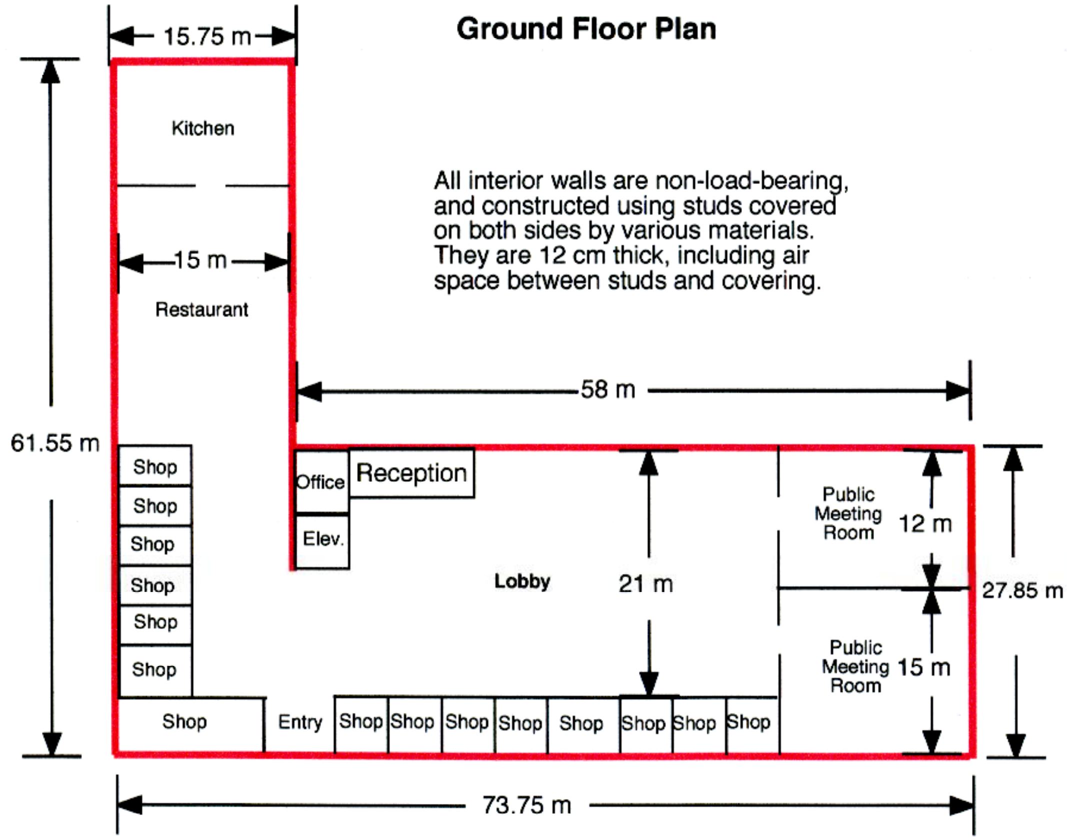


Figure 178. Framed 6-3-a floor plan.

Framed 6-3-b Floor Plan

Steel-framed, Heavy Clad Hotel

Commentary

This perspective view provides, in conjunction with the two dimensional floor plan, ready understanding to spatial relations and to how rooms may be accessed by troops entering the building.

Ground Floor

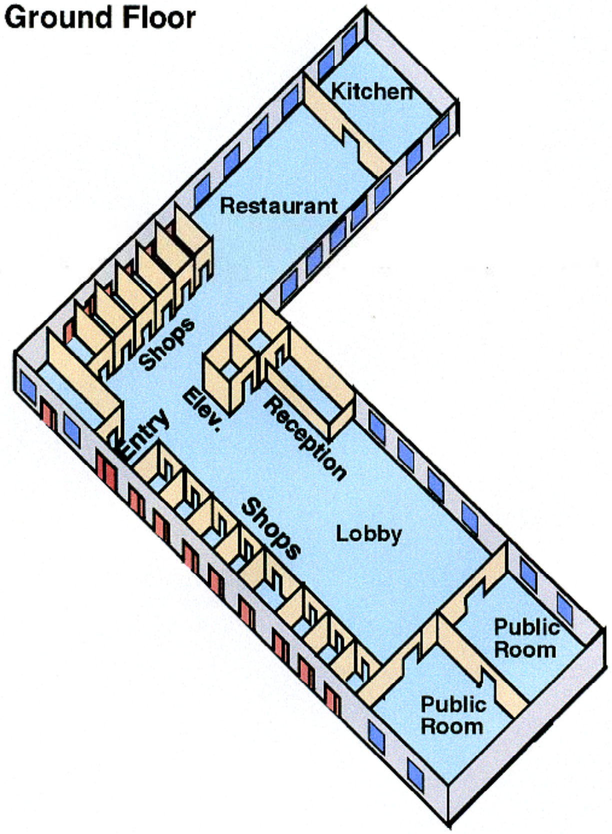


Figure 179. Framed 6-3-b floor plan.

Framed 6-3-c Floor Plan

Steel-framed, Heavy Clad Hotel

Upper Floor Plan

Commentary

Long, narrow (see measurements on a plate in this series) shapes meets the design requirement for: (1) appropriately sized guest rooms; (2) room access along corridors; (3) ventilation (at the end of each guest room); and (4) service modules (utilities, elevators, and stairs).

Guest Floor Plan

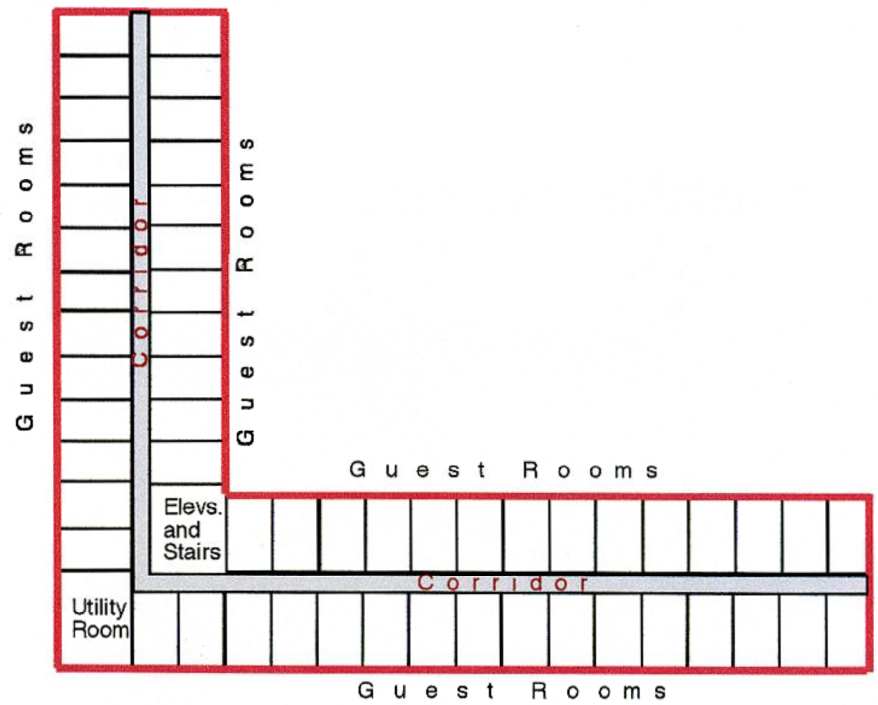


Figure 180. Framed 6-3-c floor plan.

Framed 6-3-d Floor Plan

Steel-framed, Heavy Clad Hotel

Commentary

This perspective view provides, in conjunction with the two dimensional floor plan, ready understanding to spatial relations and to how rooms may be accessed by troops entering the building.

Guest Room Floor

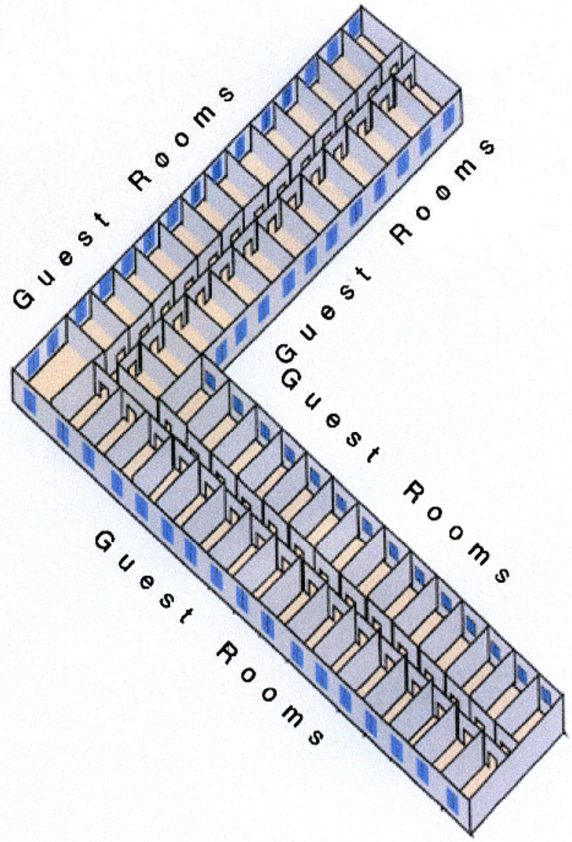


Figure 181. Framed 6-3-d floor plan.

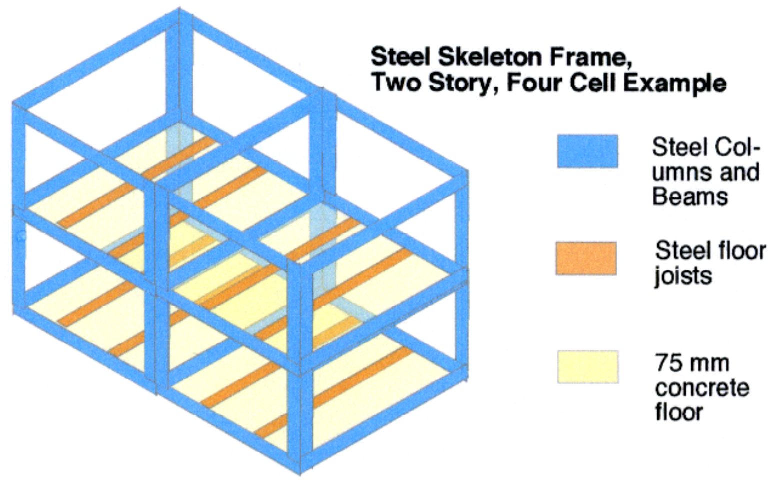
Framed 6-4 Construction

Steel-framed, Heavy Clad Hotel

Commentary

Load-bearing quality in steel framed skeleton structures comes from the connection of steel I-Beam beams to steel I-Beam columns allowing load to be transferred from the beams to the columns and thence to the ground. Floors are made using steel floor joists to support a poured concrete floor (some early structures used low brick arches, rather than concrete, for floor supports). A thin flooring material was applied on the top.

The frame commonly has a "heavy cladding," designed to protect from the elements and to impart a masonry-like appearance designed to emulate traditional mass construction buildings.



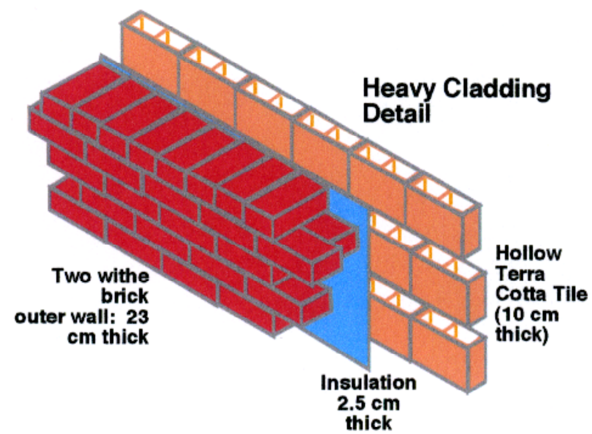


Figure 182. Framed 6-4 construction.

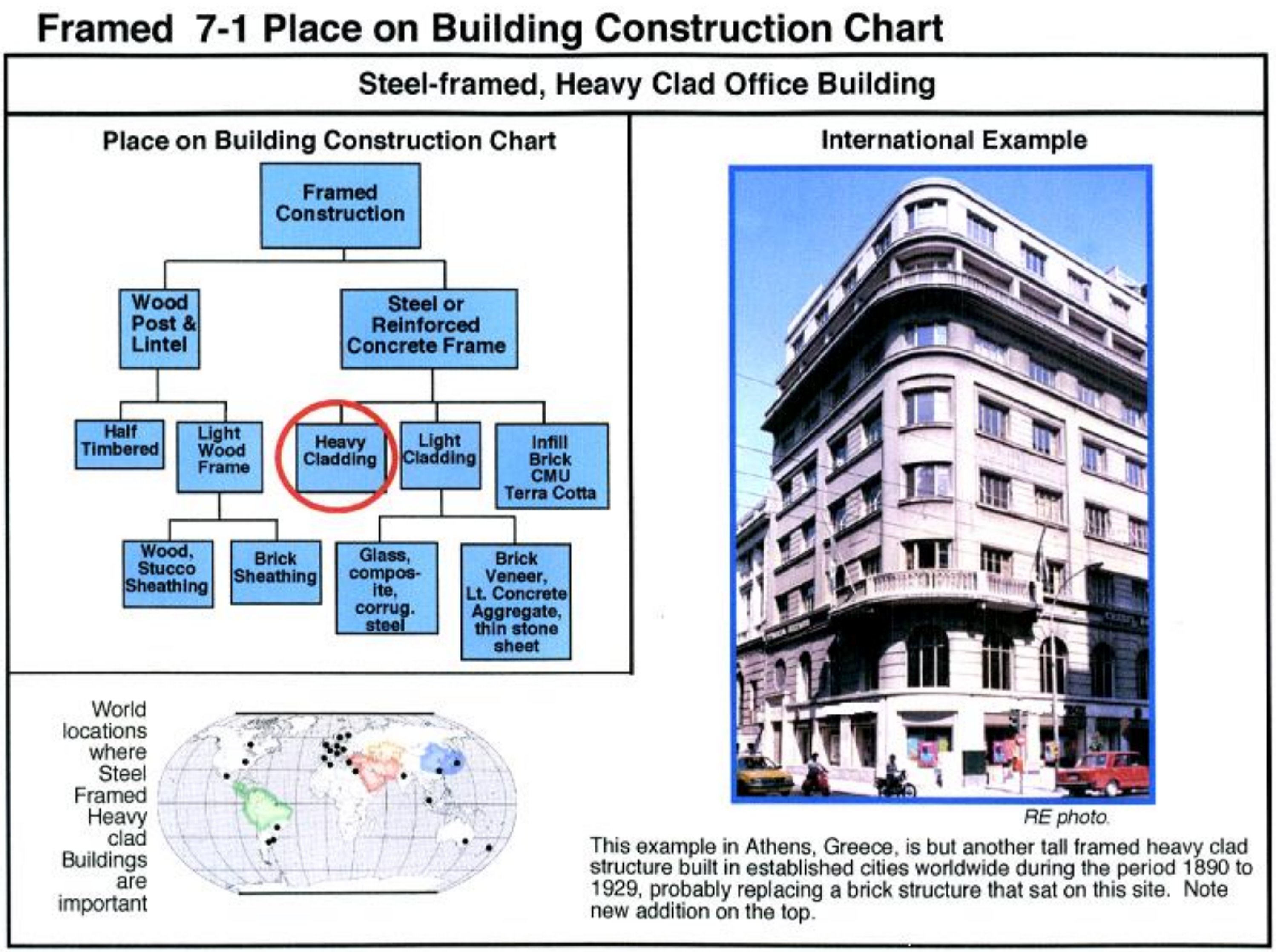


Figure 183. Framed 7-1 place on building construction chart.

Framed 7-2 Elevation

Steel-framed, Heavy Clad Office

Elevation

Commentary

Steel framed heavy-clad offices, as is the case with hotels of the same construction type, have abundant ornamentation (usually molded terra cotta) to give them a masonry-like appearance. Built in the period from 1890 through 1929, these structures have the mass structure features of: a high-ceiling pediment (often enough for a large bank office); a shaft as housing for general purpose offices (for rent); and a capital, again high-ceilinged and used for meeting rooms, clubs, etc. One can infer interior floor plan layout from the window pattern where a group of three windows lies between each column in the steel-cage structure, and would serve as venting for a single office (unless partitions are removed to combine rooms into a larger office).

Front Elevation

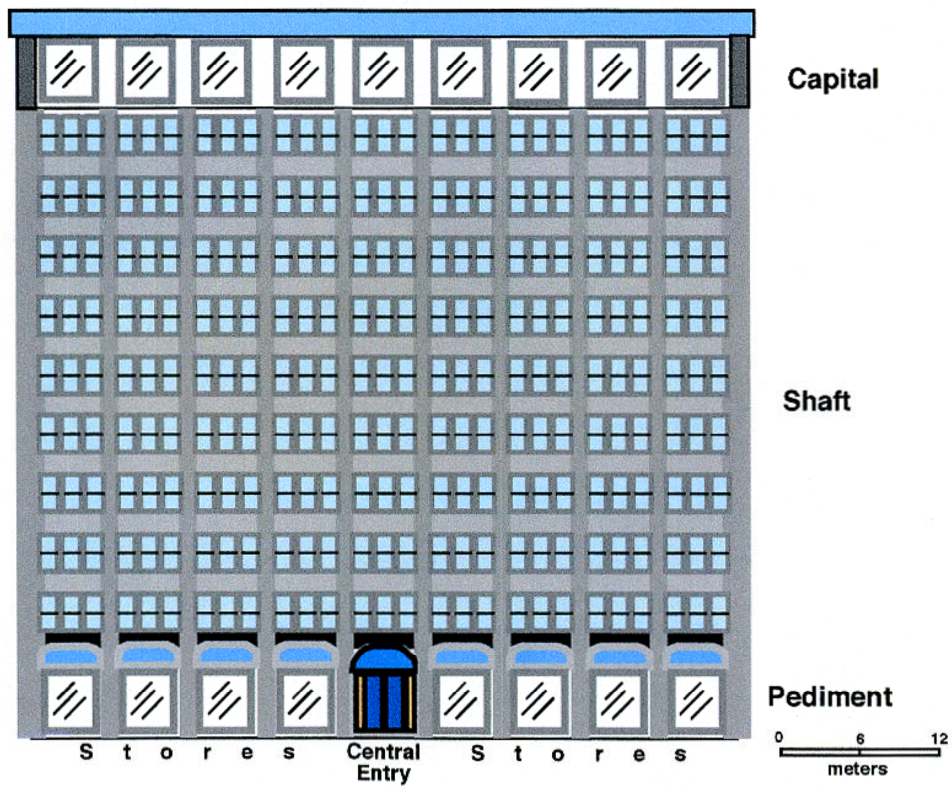


Figure 184. Framed 7-2 elevation.

Framed 7-3-a Floor Plan

Steel-framed, Heavy Clad Office

Floor Plan

Commentary

Light is provided to the rooms by either the perimeter windows or those in the light well; buildings of this girth require a light well. The outside rooms, with day long occupance, face the vented outer wall. The W.C.s, Utilities, and Service areas have less light. The vaults, of course, are windowless. Two banks occupy this floor example and share a common central entry. Entry through the central doorway leads directly to the elevator module, which stands independent of the two banks. Exterior wall is 35.5 cm thick. All interior walls are non-load-bearing, and constructed using studs covered on both sides by various materials. They are 12 cm thick, including space between studs and covering.

Ground Floor Plan

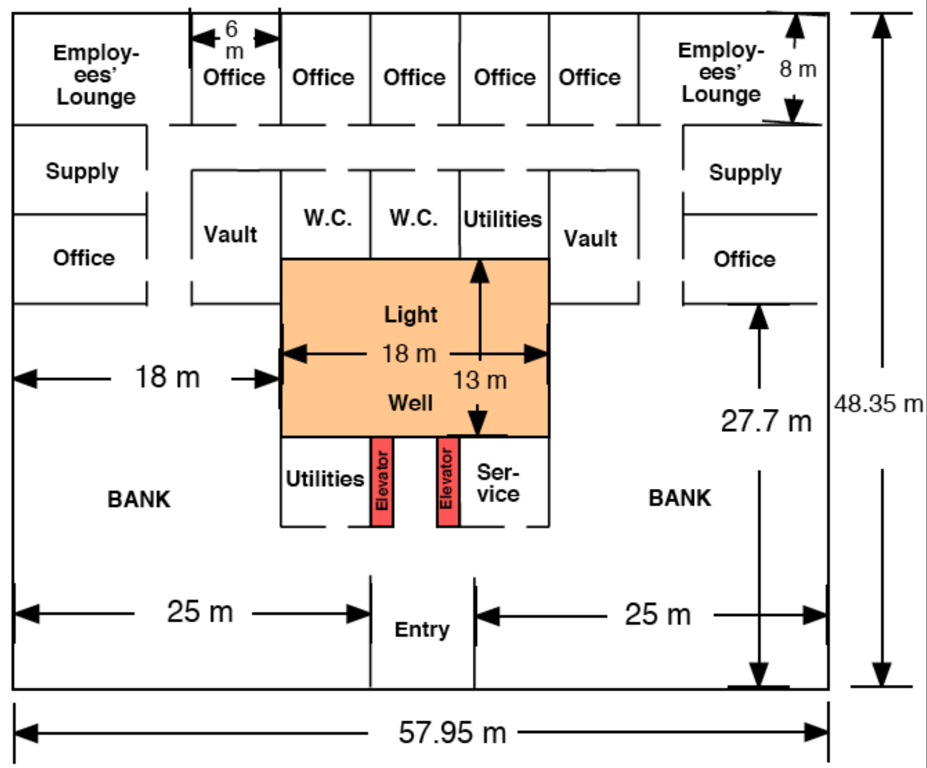


Figure 185. Framed 7-3-a floor plan.

Framed 7-3-b Floor Plan

Steel-framed, Heavy Clad Office

Commentary

This perspective view provides, in conjunction with the two dimensional floor plan, ready understanding of the building's spatial arrangement, and how rooms may be accessed by troops entering the building.

Windows are provided for the two bank offices but not for the vaults, utilities room, and Water Closets.

Ground Floor

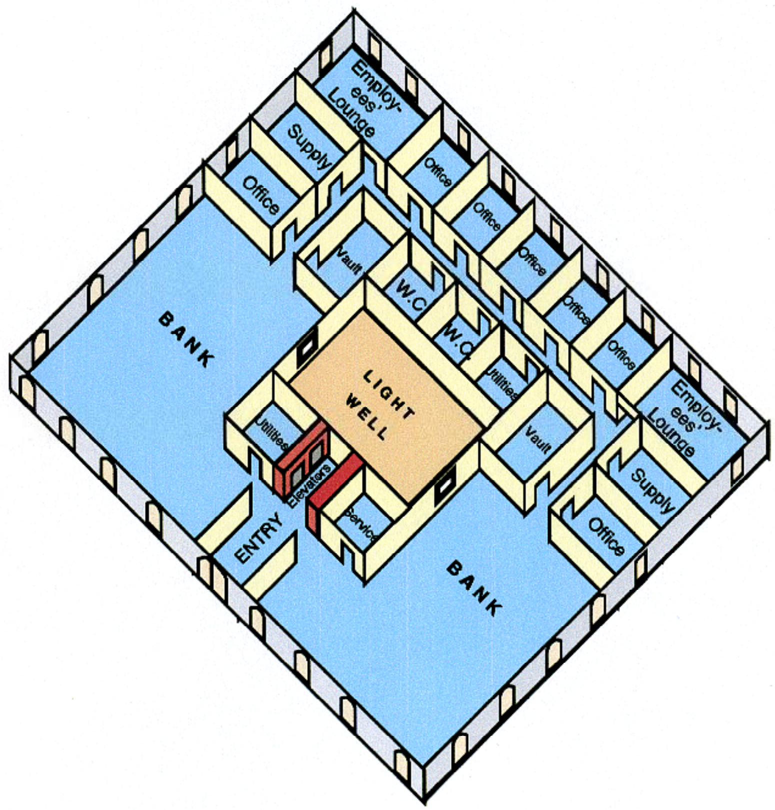


Figure 186. Framed 7-3-b floor plan.

Framed 7-3-c Floor Plan

Steel-framed, Heavy Clad Office

Commentary

As with the ground floor plan, offices have access to venting via the exterior wall of the building and the light well (albeit at lower light values). The corridor accesses the elevator and reaches all offices.

Upper Floor (offices)

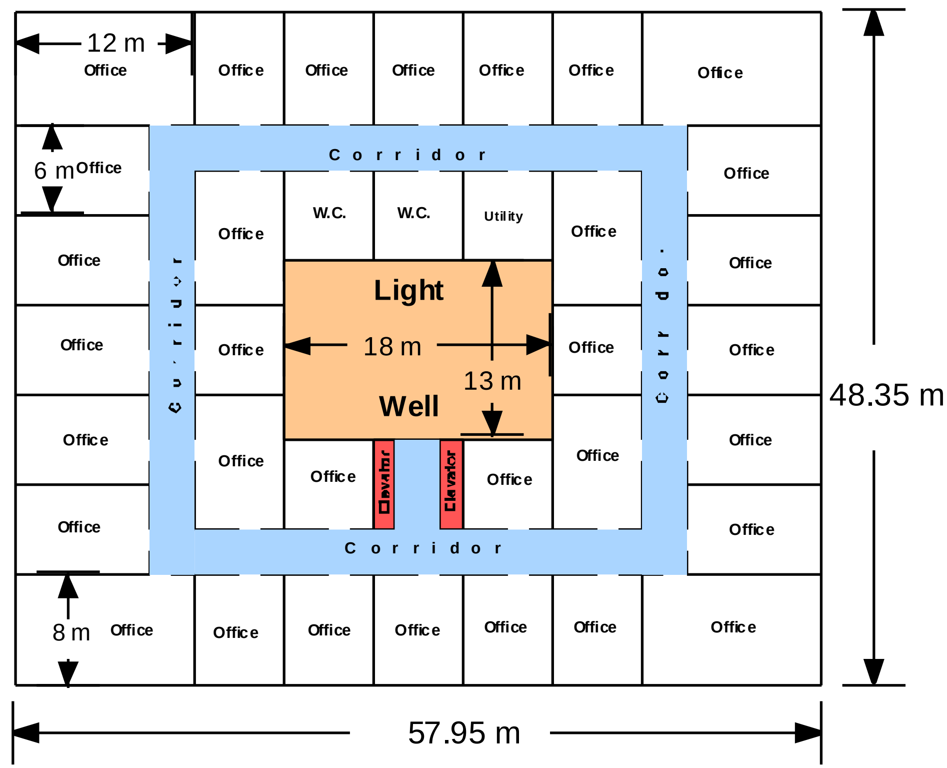


Figure 187. Framed 7-3-c floor plan.

Framed 7-3-d Floor Plan

Steel-framed, Heavy Clad Office

Commentary

This perspective view provides, in conjunction with the two dimensional floor plan, ready understanding of the building's spatial arrangement, and how rooms may be accessed by troops entering the building.

Upper Floor

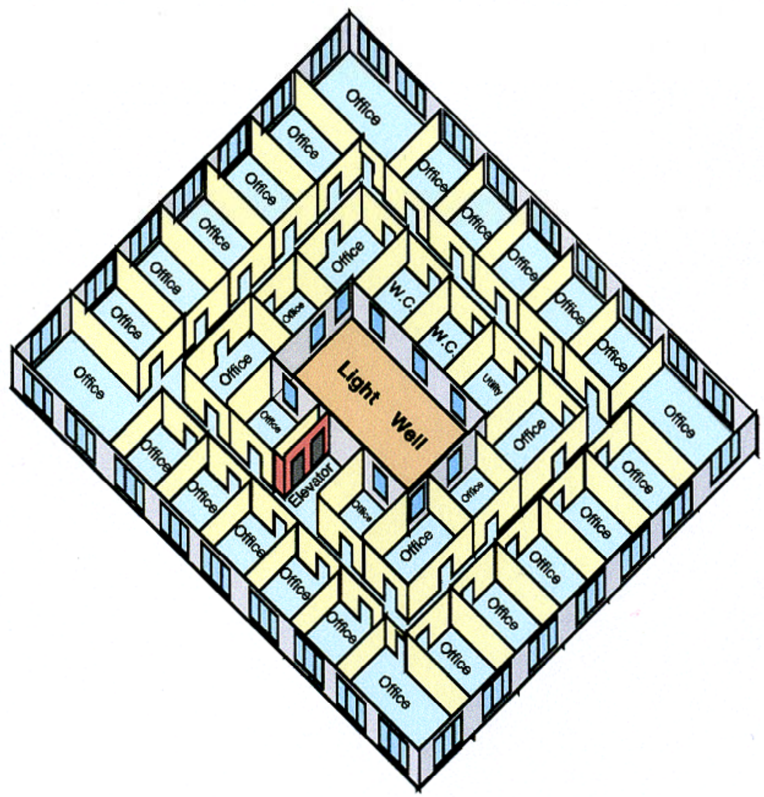


Figure 188. Framed 7-3-d floor plan.

Framed 7-4-a Construction

Steel-framed, Heavy Clad Office Building

Commentary

Load-bearing quality in steel framed skeleton structures comes from the connection of steel I-Beam beams to steel I-Beam columns allowing load to be transferred from the beams to the columns and thence to the ground. Floors are made using steel floor joists to support a poured concrete floor (some early structures used low brick arches, rather than concrete, for floor supports). A thin flooring material was applied on the top.

Steel Skeleton Frame, Two Story, Four Cell Example

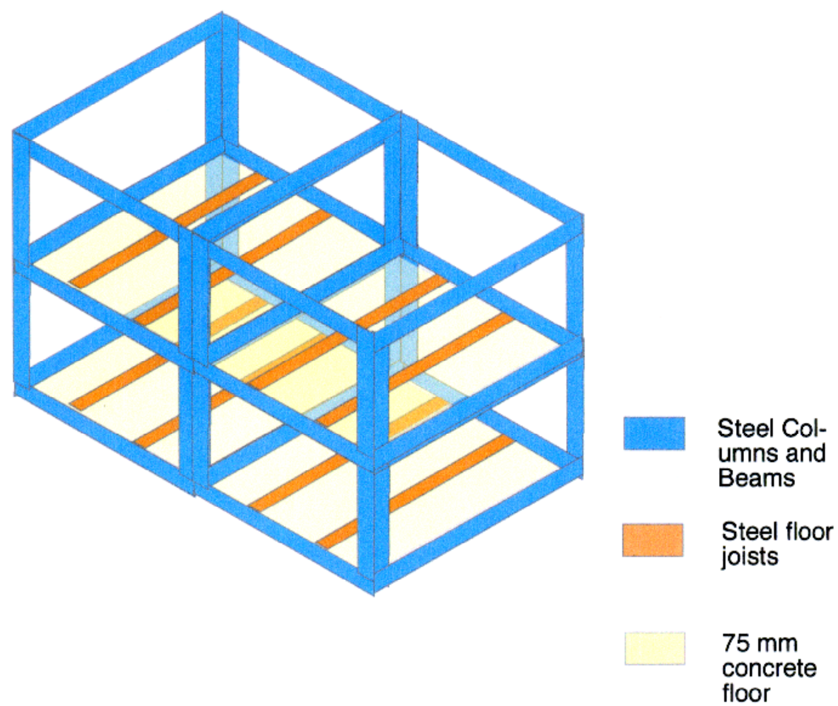


Figure 189. Framed 7-4-a construction.

Framed 7-4-b Construction

Steel-framed, Heavy Clad Office Building

Construction Details

Commentary

A wide variety of connectors has been devised to tie columns to beams, floor/ceiling joists to beams and columns, and floor to joists.

Steel frame Connections

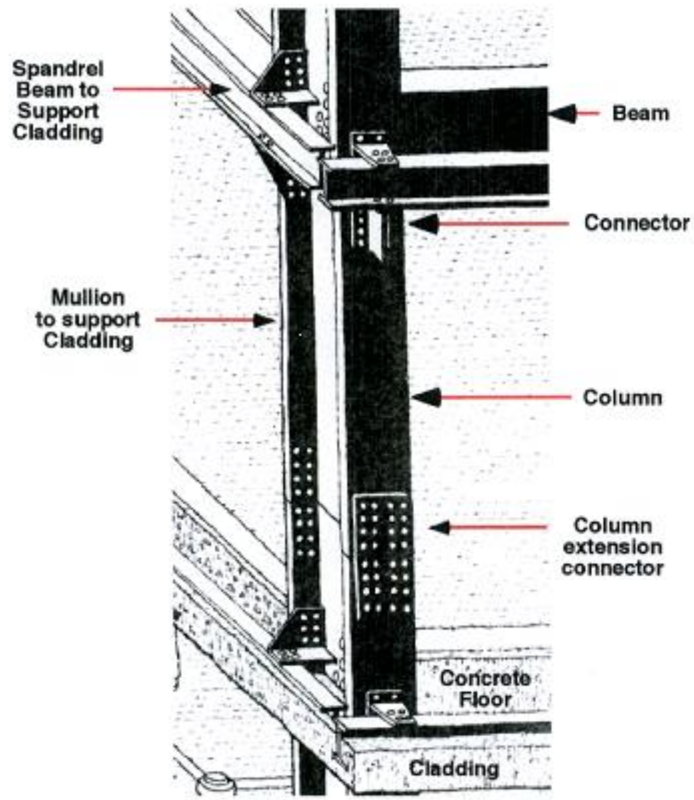


Figure 190. Framed 7-4-b construction.

Framed 7-4-c Construction

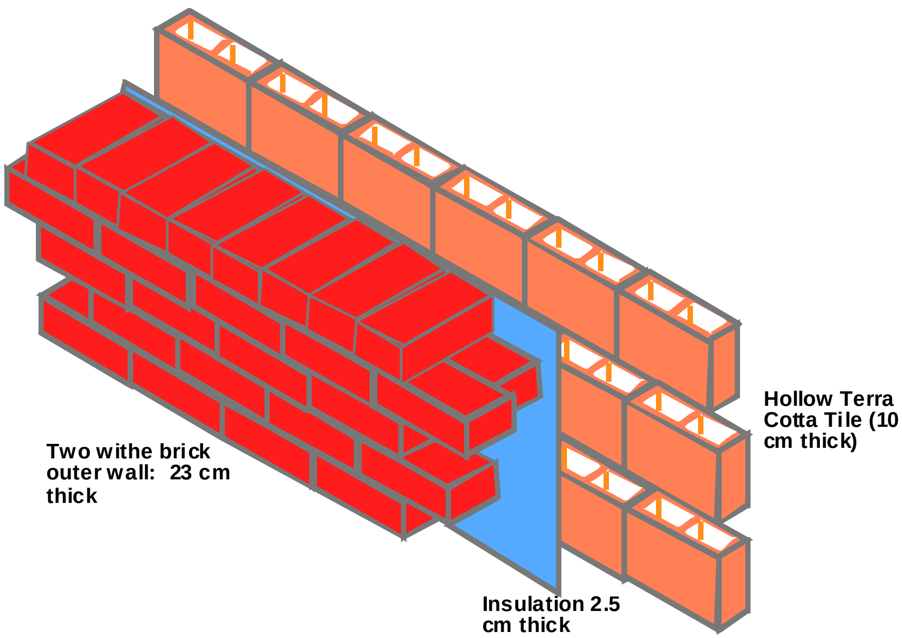
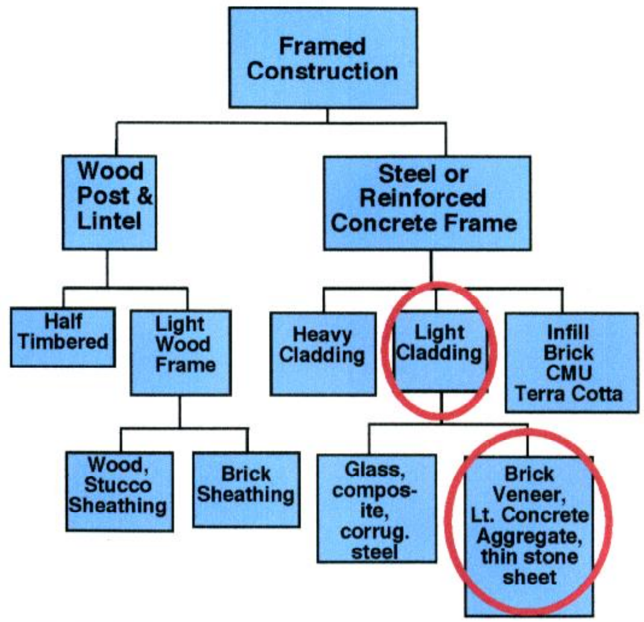
Steel-framed, Heavy Clad Office Building	
Construction Details	
Commentary In order to achieve a masonry-like appearance, designers of steel framed, heavy clad buildings (while at the same time sealing the frame from the elements) used hollow terra cotta tile (10 cm thick), then a layer of insulation (2.5 cm), topped by a double brick outer wall. The combination of the three elements is connected to steel frame members, columns, beams, and mullions.	**Heavy Cladding Components** 

Figure 191. Framed 7-4-c construction.

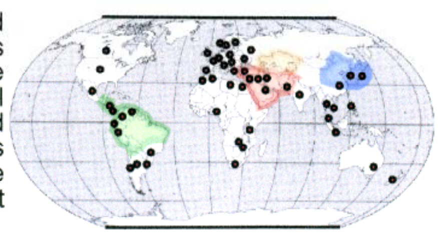
Framed 8-1 Place on Building Construction Chart

R/C Framed Light Clad Apartment Building

Place on Building Construction Chart



World locations where R/C-Steel Light clad buildings are important



International Example

RE Photo

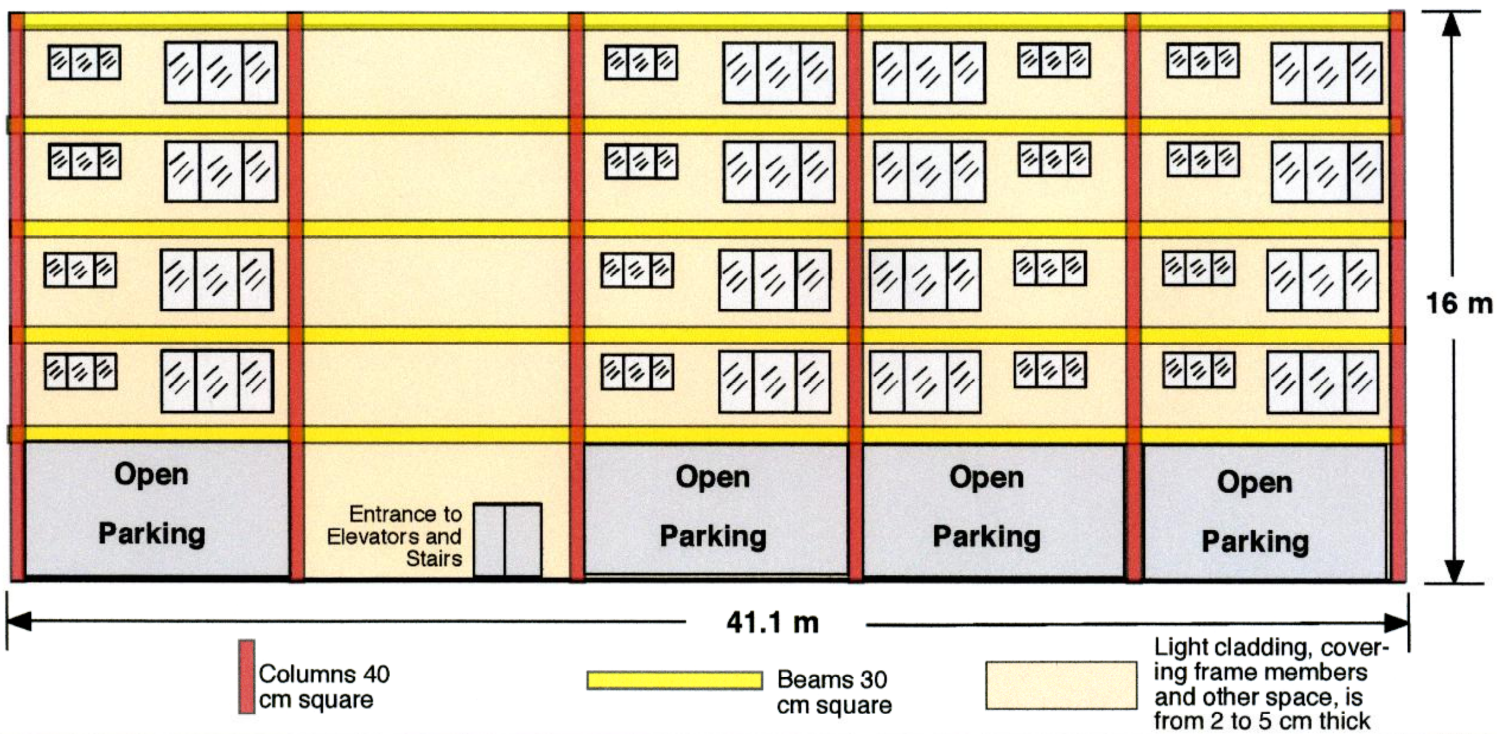
An R/C framed apartment building is in the process of having light cladding applied over the frame; venting pattern and the balconies reveal it as an apartment building. The thick columns and the concrete floors are visible.

Figure 192. Framed 8-1 place on building construction chart.

Framed 8-2 Elevation

R/C Framed Light Clad Apartment Building

Venting Pattern



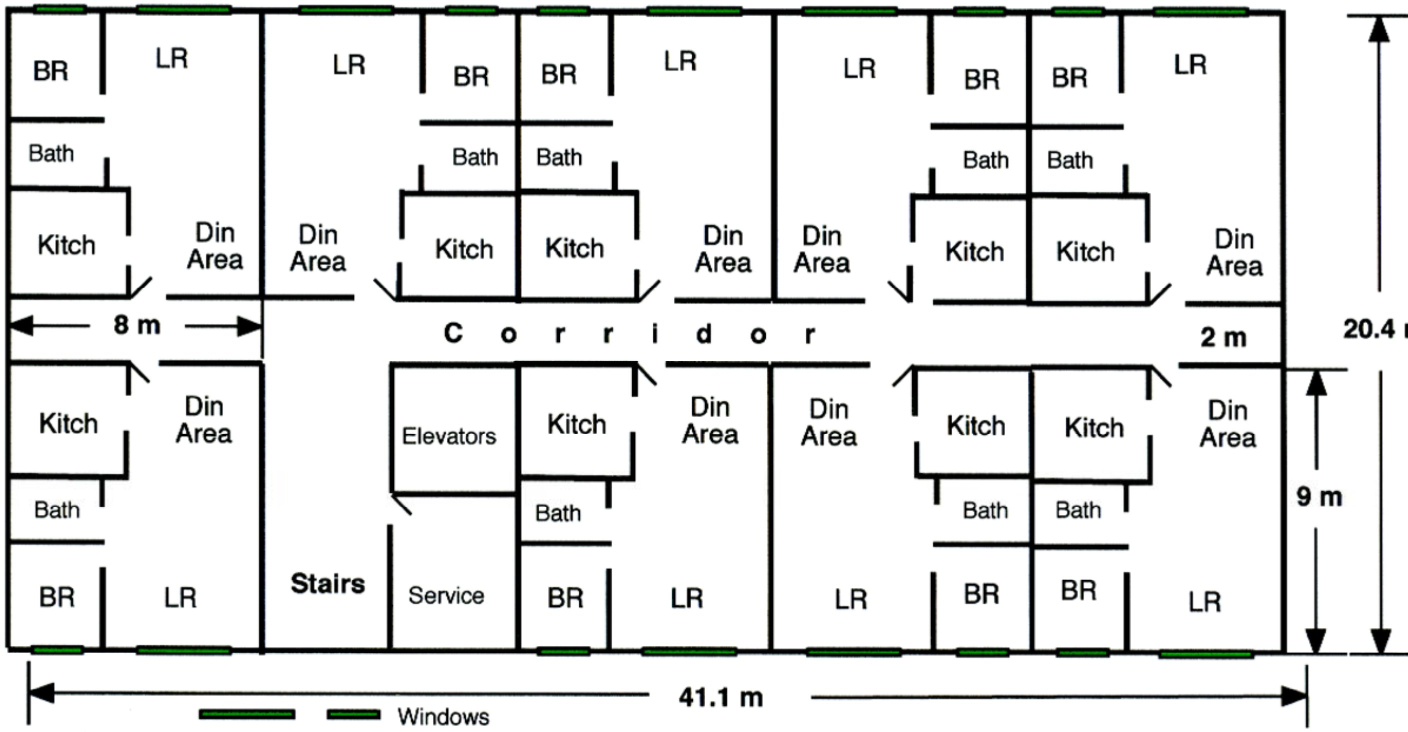
Commentary	Venting pattern of a r/c framed apartment building: single apartment units (on the four upper floors in this example) lie between the columns and the beams. The larger windows are for the living rooms. The ground floor is left open to provide parking spaces for the building's inhabitants. Other ground floor space is used for storage units and for the building's utilities. See floor plan to see window placement.

Figure 193. Framed 8-2 elevation.

Framed 8-3-a Floor Plan

R/C Framed Light Clad Apartment Building

Floor plan of Apartment Units on an Upper Floor



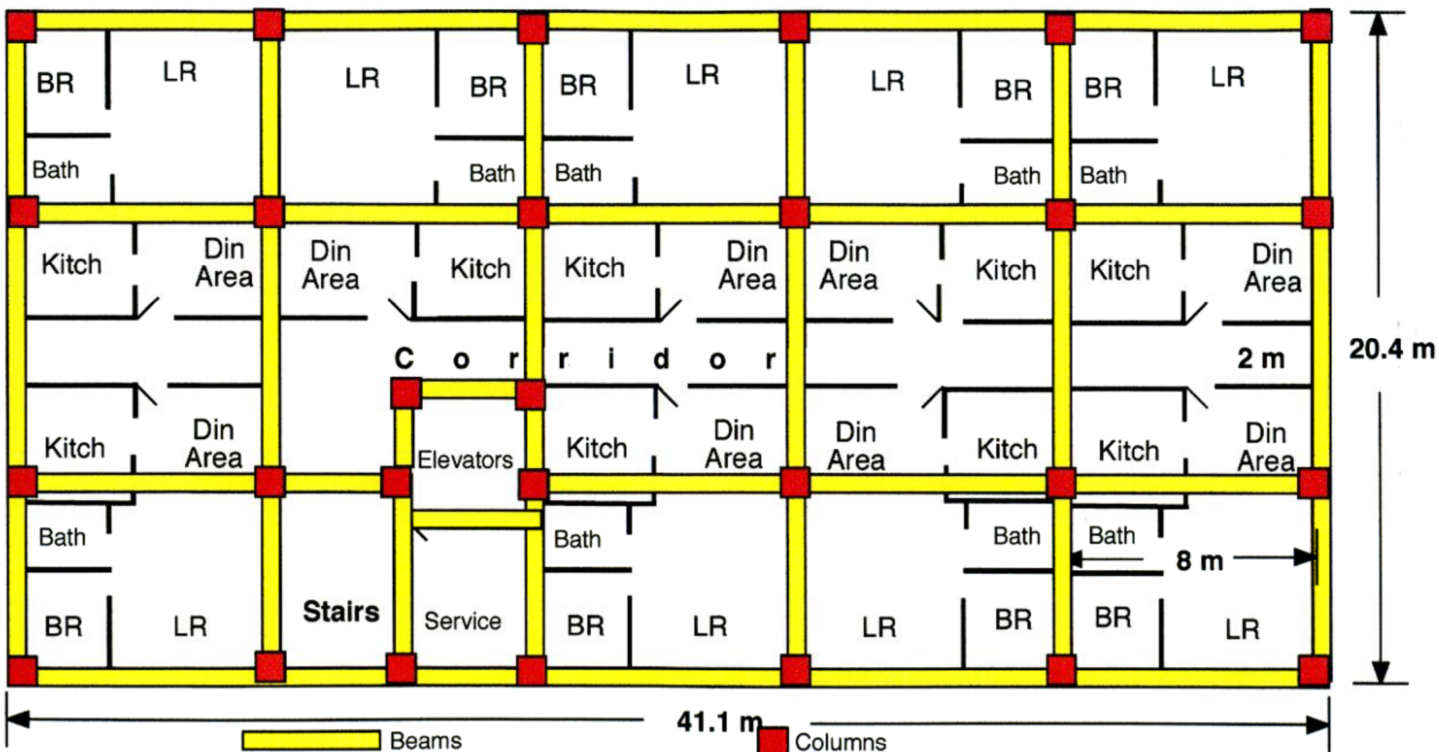
Commentary	This floor plan of apartments on an upper floor is representative of an international type. It employs a central corridor, one that provides venting for each unit's living room and bedroom. Plumbing for bathrooms and kitchens for each pair of units achieves maximum efficiency. With units of the size shown here, the central corridor configuration does not allow for exterior venting for kitchen and bath. Units are small, measuring only 72 square meters each and have only a single bedroom. Larger units can be achieved by rearrangement of the interior non-load-bearing partitions. Note revealing venting pattern.

Figure 194. Framed 8-3-a floor plan.

Framed 8-4 Construction

R/C Framed Light Clad Apartment Building

Column and Beam construction (Apartment Building, upper floor)



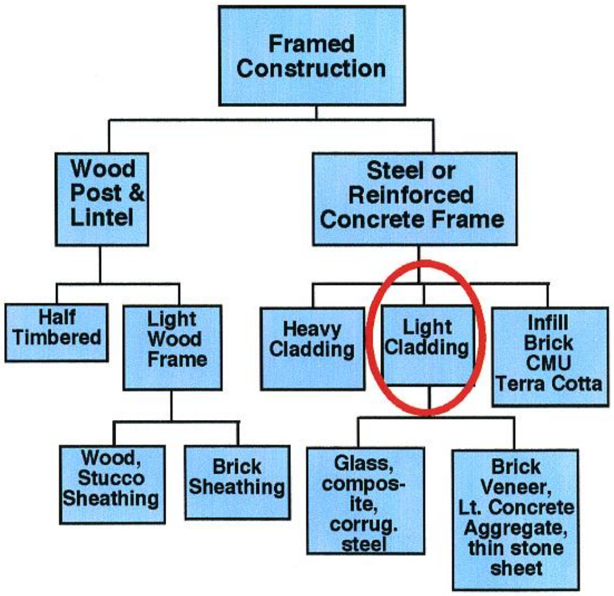
Commentary	A planimetric view of reinforced concrete columns and beams of an apartment building floor. Columns are square, measuring 40 cm on a side. Beams are also square, 30 cm on a side. Connections are assumed to meet international standards. Interior partitions between and within the apartment units are non-load-bearing; the standard of using light weight studs (wood or metal) and general wall material (plywood, drywall, etc.). Note that interior partitions are independent of the structural columns and beams.

Figure 195. Framed 8-4 construction.

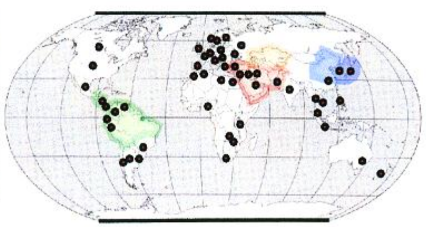
Framed 9-1 Place on Building Construction Chart

RC Framed Construction Hotel, Light Clad

Place on Building Construction Chart



World locations where R/C-Steel Light clad buildings are important



International Example

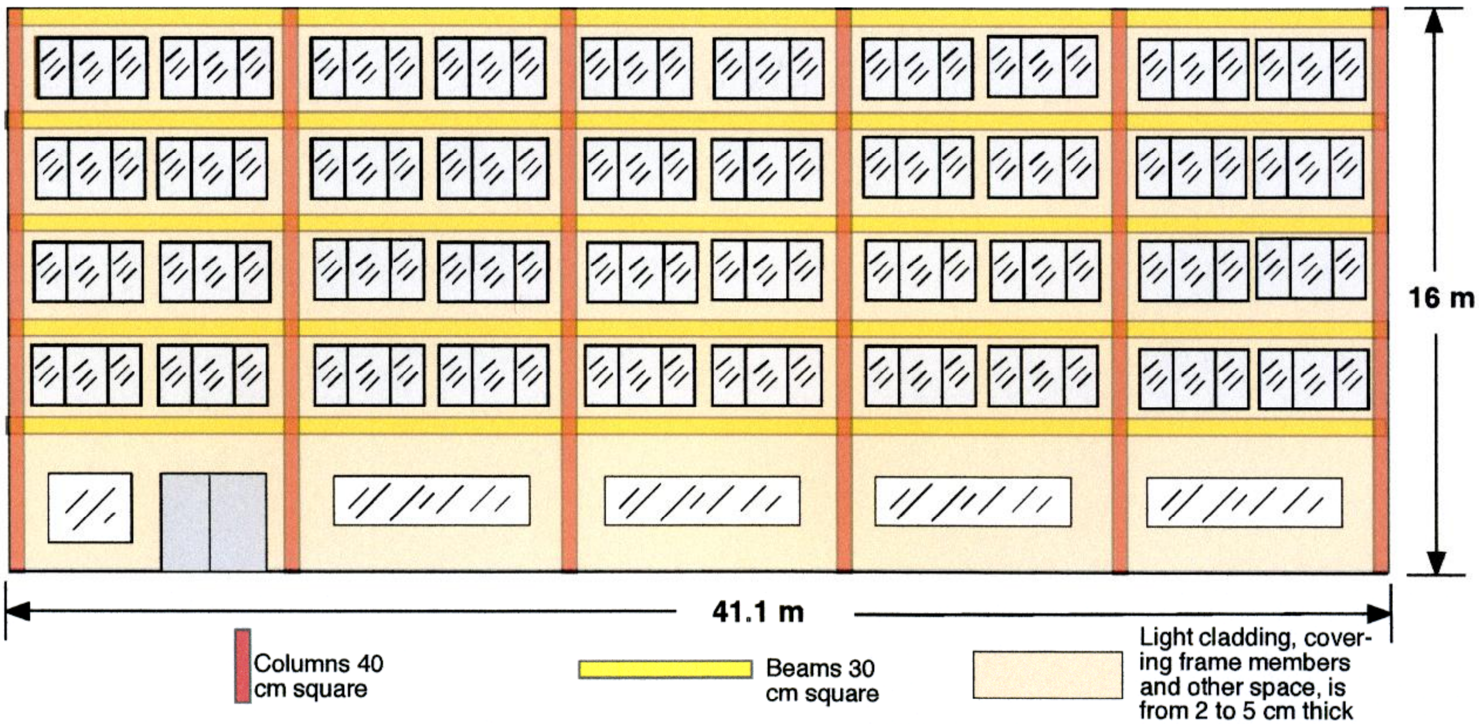
RE photo

International hotel chains frequently employ framed light clad type construction to fulfill their needs. The advantages of standardization of design (standard room size, etc.) is economic for large corporations. The venting pattern in this example is called *spandrel*, as the horizontal windows and cladding follow along horizontal spandrel beams.

Figure 196. Framed 9-1 place on building construction chart.

Framed 9-2 Elevation

RC Framed Construction Hotel, Light Clad



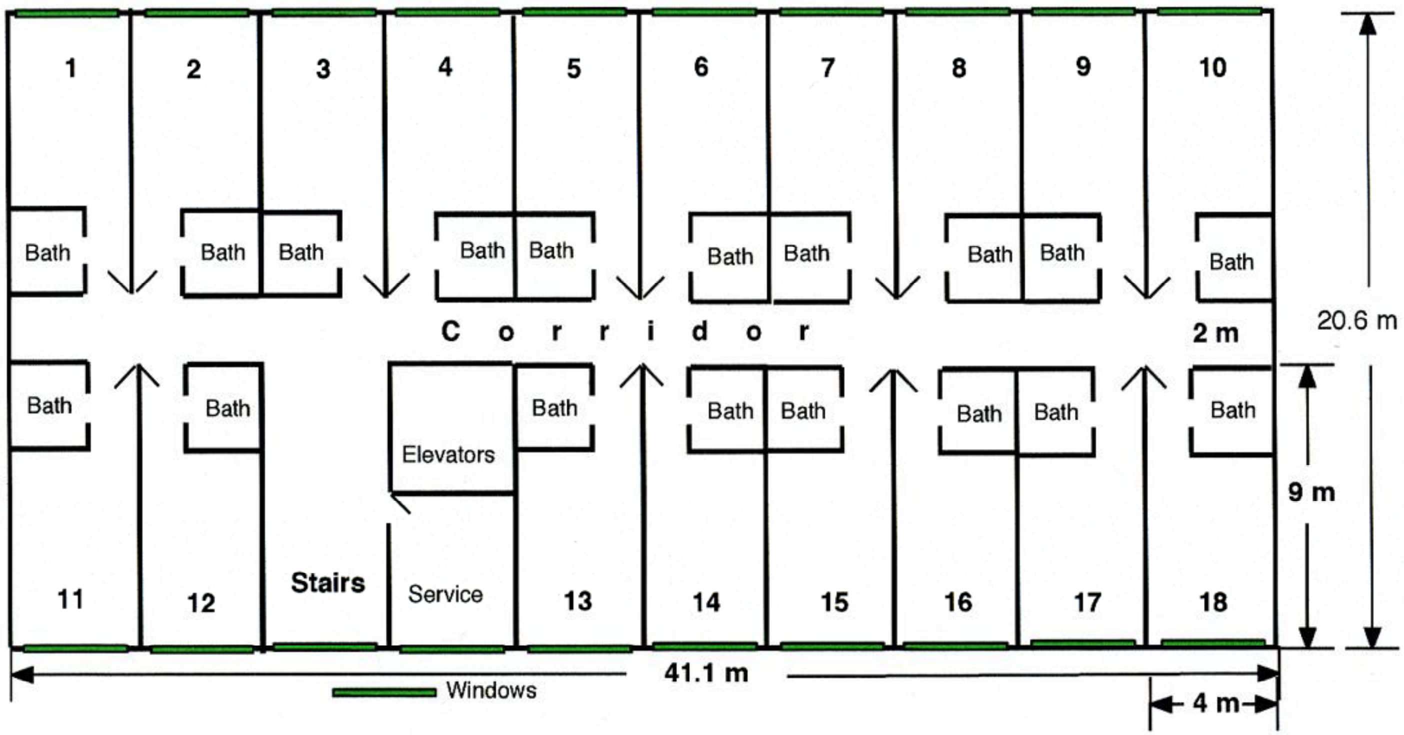
Commentary	Venting pattern of a r/c framed hotel: two 4m guest rooms (on the four upper floors in this example) lie between sets of two columns. Thus, windows are large forming almost all of the end wall of each guest room (providing its only natural lighting, see floor plan). The ground floor differs. It is taller (has higher ceilings) and provides space for public functions, i.e., lobby, restaurant, business office, and public meeting rooms. All non vented wall surface is a light cladding covering the frame and spaces between.

Figure 197. Framed 9-2 elevation.

Framed 9-3-a Floor Plan

RC Framed Construction Hotel, Light Clad

Floor plan of Hotel Guest Rooms on an Upper Floor



Commentary	This hotel floor plan is representative of an international type; 18 numbered guest rooms are shown. The plan employs a central corridor, one that provides venting (for light) at one end of the room. Consequently, windows are large forming a high percentage of the room's end wall; the corridor is a standard 2 meters wide (required for foot traffic and moving room furniture). Bathrooms are "back to back" for efficient plumbing use. Room width of four meters is sufficient to allow for a two meter bed and furniture. Rooms often have lockable doors connecting an adjacent room.

Figure 198. Framed 9-3-a floor plan.

Framed 9-3-b Floor Plan

RC Framed Construction Hotel, Light Clad

Commentary

Common dimensions are used here: corridors are 2 meters wide; rooms (including bath) are 4 x 8 meters; baths are 2 x 2 meters. Efficient use of plumbing is achieved by back-to-back baths. Beams span 8 meters between columns. Partitions use 12 cm stud walls (in many older, steel-framed heavy clad hotels these walls use lath and plaster).

Guest Rooms Detail

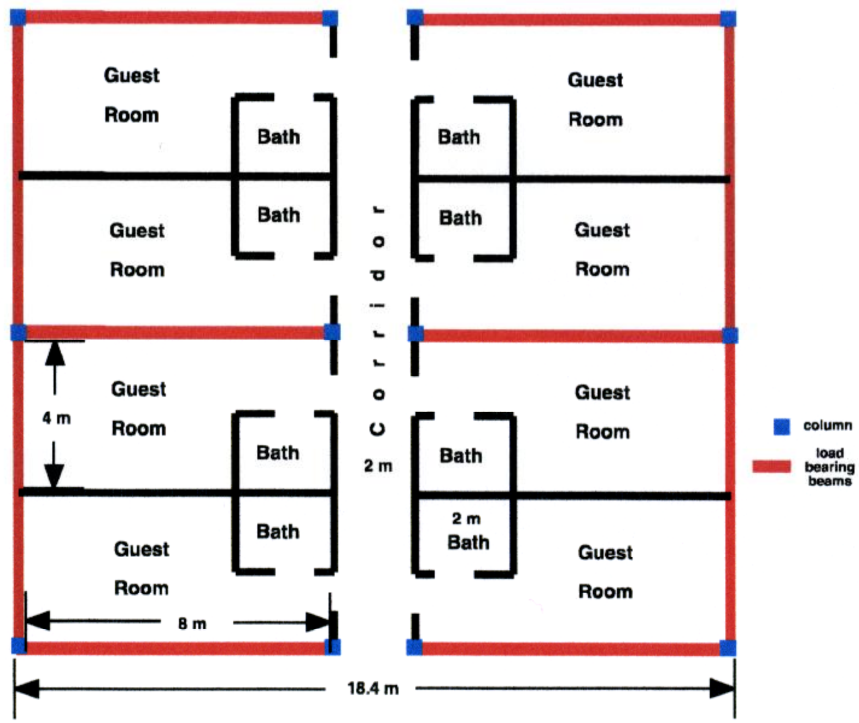


Figure 199. Framed 9-3-b floor plan.

Framed 9-3-c Floor Plan

RC Framed Construction Hotel, Light Clad

Commentary

This isometric view provides, in conjunction with the two dimensional floor plan, ready understanding to spatial relations and to how rooms may be accessed by troops entering the building.

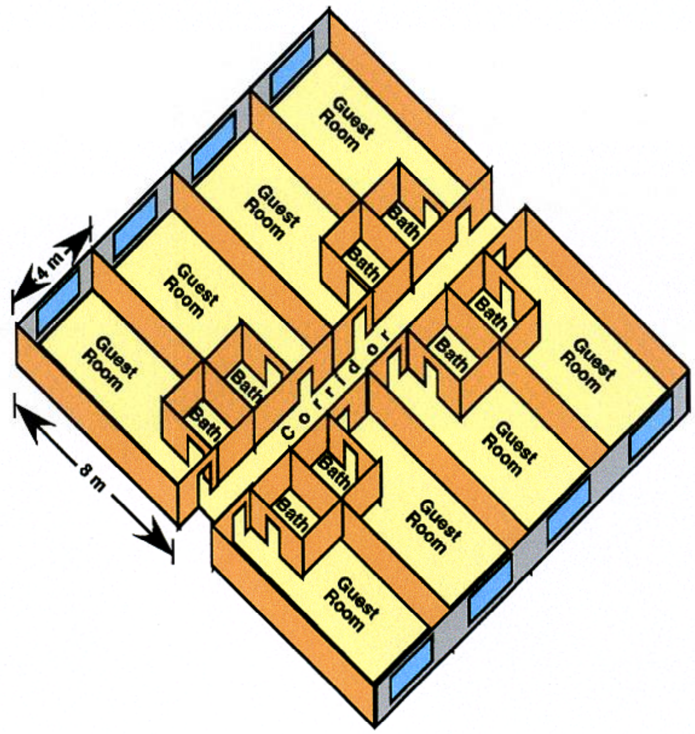
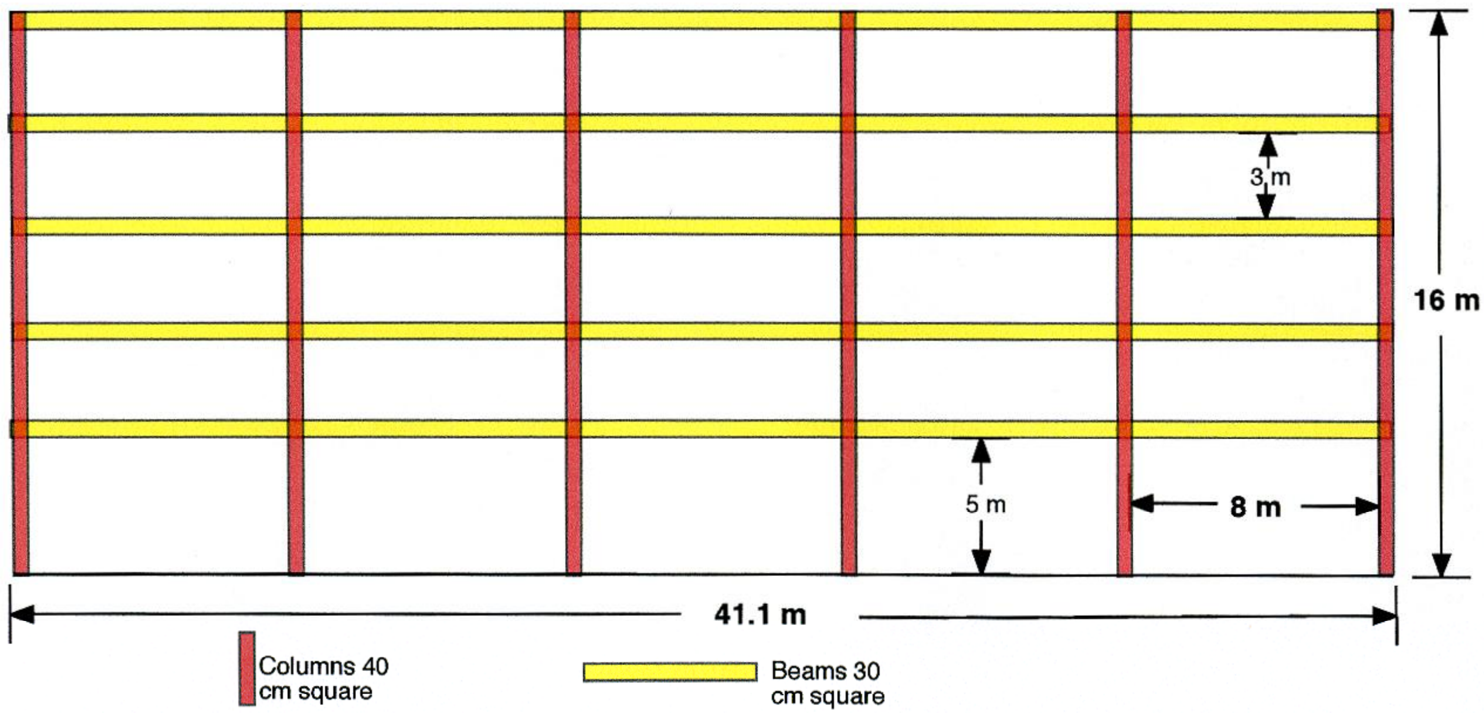


Figure 200. Framed 9-3-c floor plan.

Framed 9-4-a Construction

RC Framed Construction Hotel, Light Clad

Reinforced Concrete Frame (Columns and Beams)



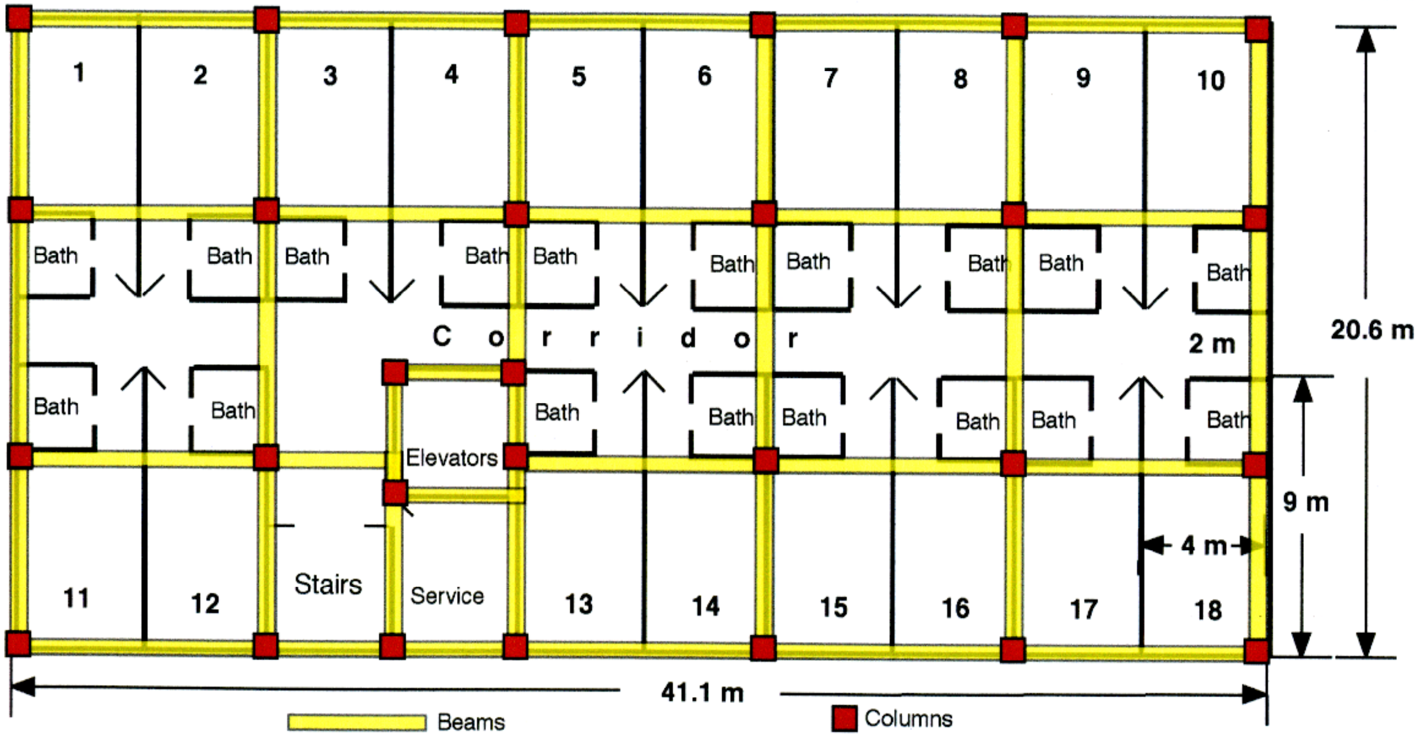
Commentary	All load (dead and live) is carried by steel reinforced concrete columns and beams (weight on reinforced concrete floors is transferred to the beams, and in turn transferred to the ground via the columns). The use of reinforcement permits spans between columns to be 8 meters (note: this span is greater than a traditional steel skeleton frame where spans are 4 or 5 meters). Four upper floors are 3 meters high: the ground floor (to house diverse functions) is 5 meters high.

Figure 201. Framed 9-4-a construction.

Framed 9-4-b Construction

RC Framed Construction Hotel, Light Clad

Column and Beam construction (Hotel, upper floor)



Commentary	A planimetric view of reinforced concrete columns and beams of a hotel building guest floor. Columns are square, measuring 40 cm on a side. Beams are also square, 30 cm on a side. Connections are assumed to meet international standards. Interior partitions between and within the hotel guest rooms are non-load-bearing; the standard uses light weight studs (wood or metal) and general wall material (plywood, drywall, etc.). Interior partitions do not necessarily match the structural columns and beams.

Figure 202. Framed 9-4-b construction.

Framed 9-4-c Construction

RC Framed Construction Hotel, Light Clad

Construction Method and Dimensions

Commentary

Many fundamental characteristics of re-enforced concrete framed buildings are seen in the example, from Tel Aviv.

The intended function of the building will be that of a hotel, judging from the venting pattern. The cladding is light, being some highly reflective material; it is affixed to light weight mullions (vertical members). The columns are made of reinforced concrete, spaced some four meters apart. Column shapes vary from square to rectangular, ranging from 30 x 30 cm to 30 by 50 cm. The floor/ceilings are also of concrete (commonly some 10 to 15 cm thick. The lower three stories — serving functions such as public gathering, lobby, and restaurants — have what is probably foamed concrete cladding, to give the impression of stability and strength.

Strengths:

R/C columns: 356 kg/cm^2

R/C floors: 356 kg/cm^2

Concrete Framed building under construction in Tel Aviv

RE Photo

Figure 203. Framed 9-4-c construction.

Framed 10-1 Place on Building Construction Chart

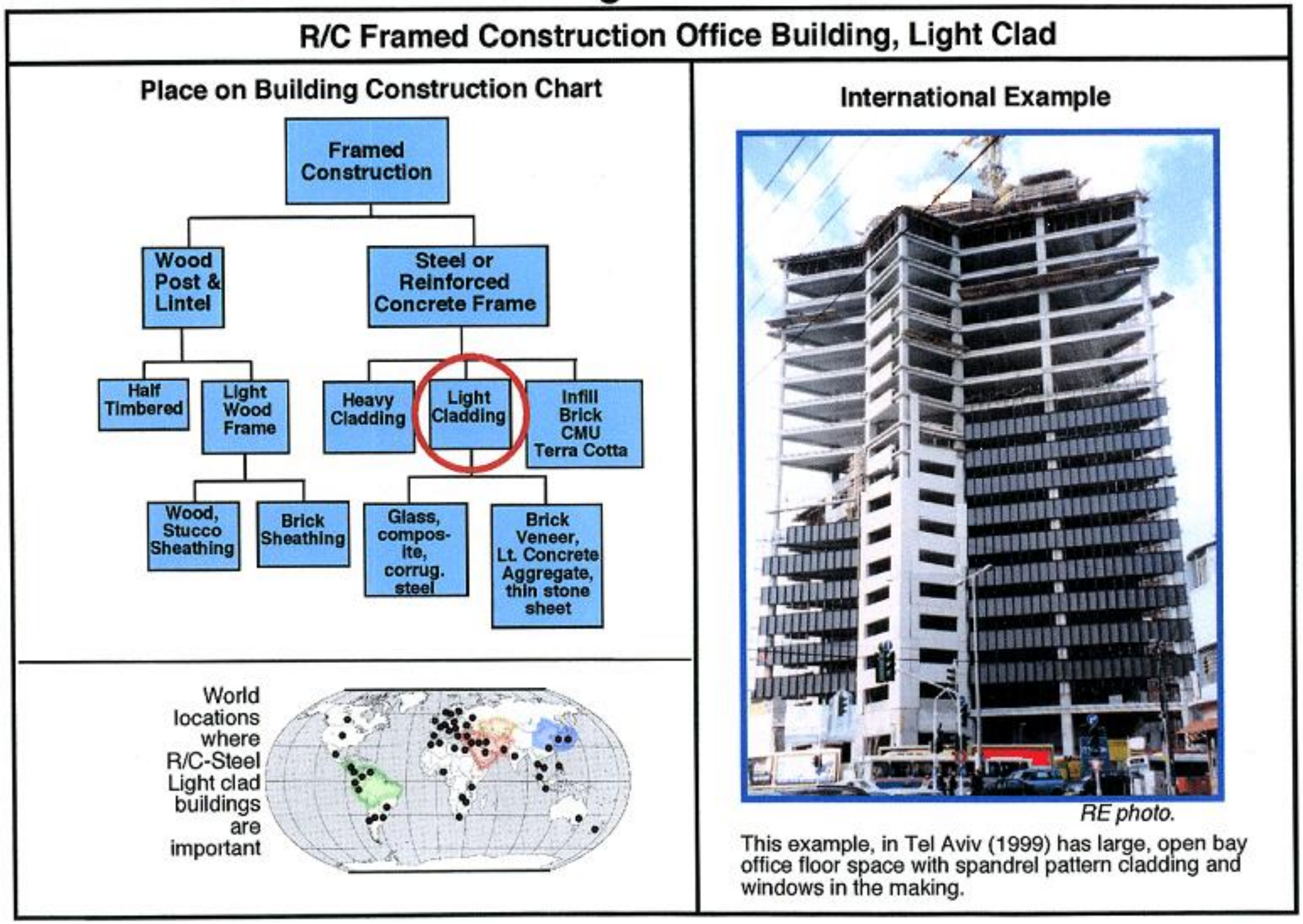
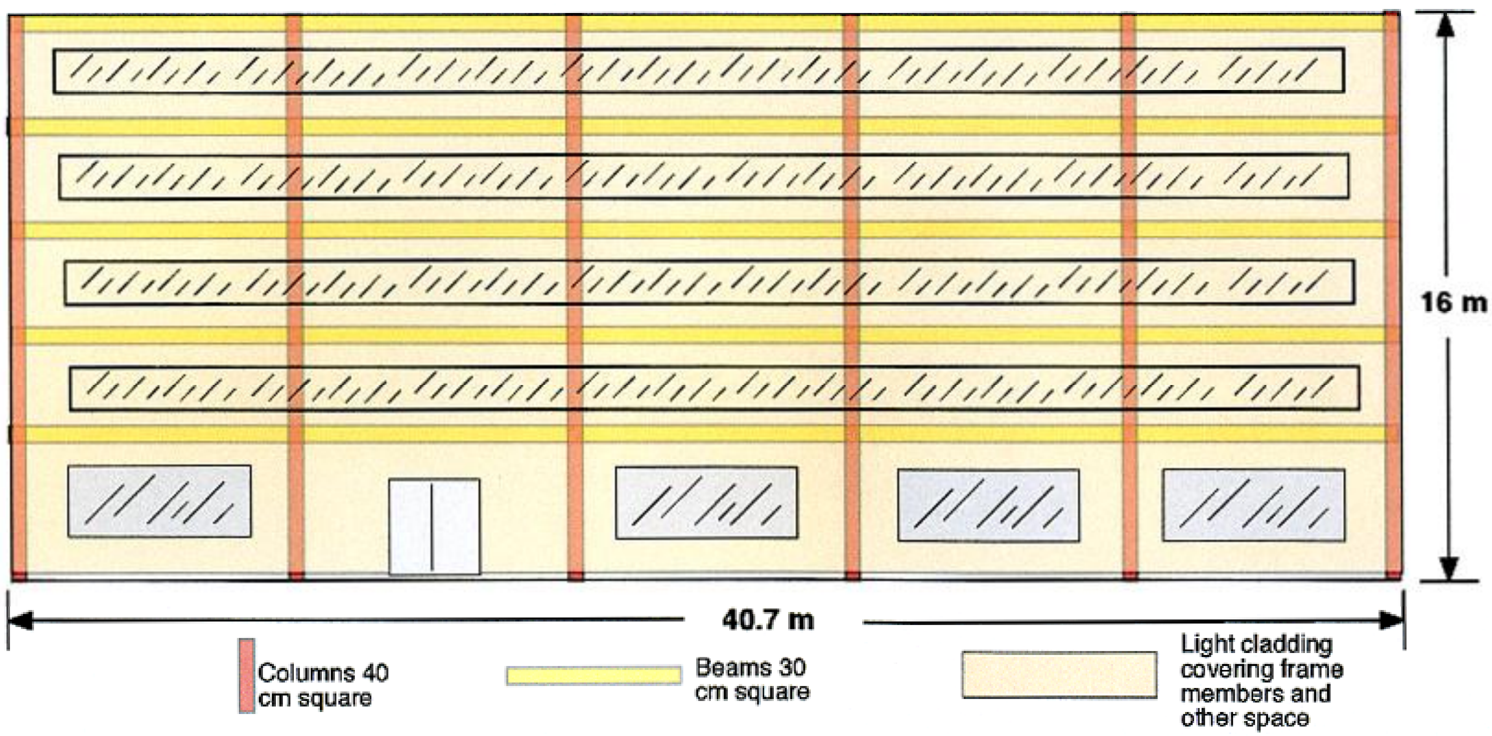


Figure 204. Framed 10-1 place on building construction chart.

Framed 10-2 Elevation

R/C Framed Construction Office Building, Light Clad

Venting Pattern



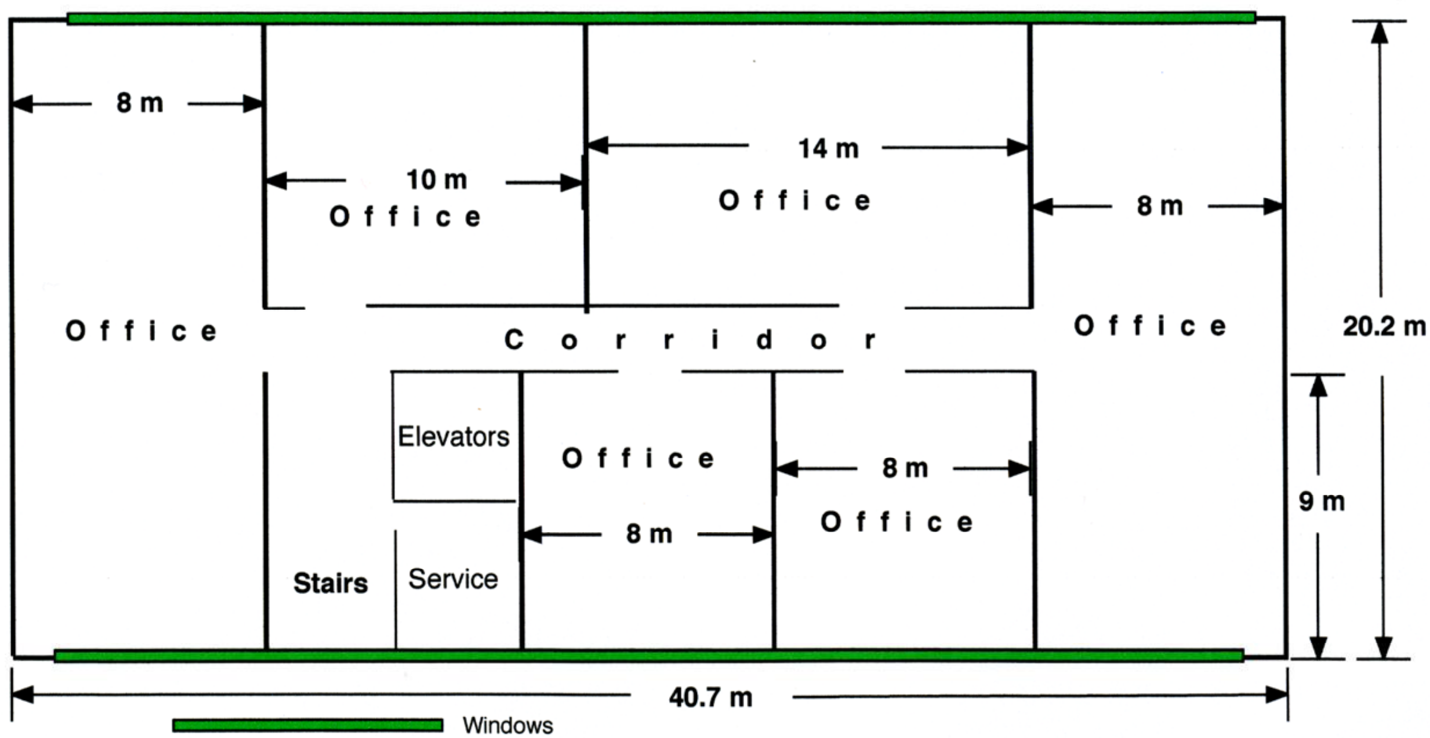
Commentary	Venting pattern of a r/c framed office building, in this case employing (for the upper floors) a *Spandrel* pattern (where the window is building-long and parallel with the spandrel beams). Interior partitions, within the offices, do not usually coincide with the structural columns, and can be seen through the windows. The ground floor, with its access to the passing trade on the street, are often devoted to higher value uses, such as a retail store or an office with direct connections to customers. See office floor plan.

Figure 205. Framed 10-2 elevation.

Framed 10-3-a Floor Plan

R/C Framed Construction Office Building, Light Clad

Floor plan of Office Units on an Upper Floor



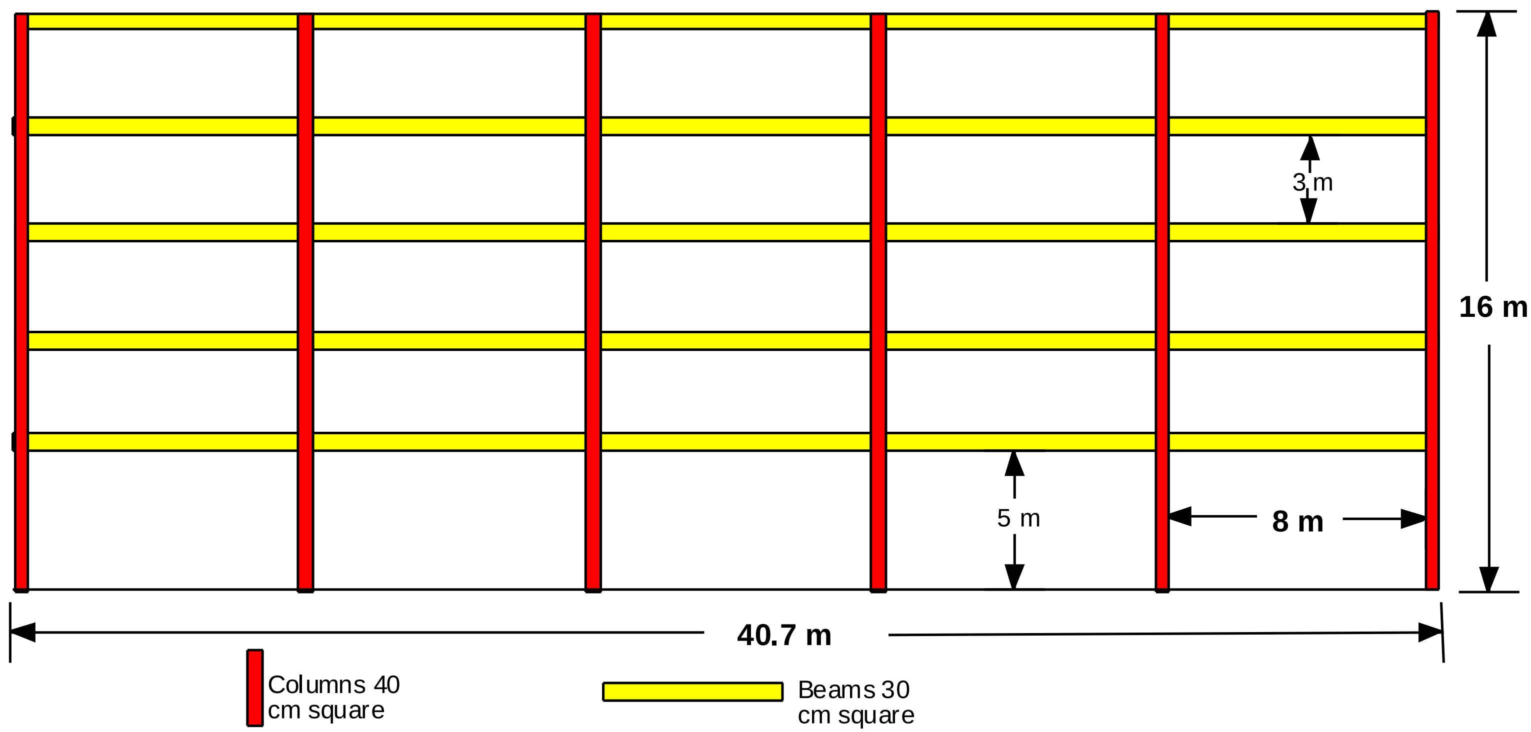
Commentary	This floor plan of offices on an upper floor is representative of an international type. It employs a central corridor, one that provides venting for each unit with a Spandrel (horizontal, parallel with the structural beams) pattern. Offices are readily configured in accordance with a firm's needs through the placement of non-load-bearing partitions. In this example, the floor is configured to provide six offices. In other situations, given the same size building footprint, the number of offices per floor can vary from one to many. The spandrel window pattern clearly identifies, from external view, the floor as having an office function.

Figure 206. Framed 10-3-a floor plan.

Framed 10-4-a Construction

RC Framed Construction Office Building, Light Clad

Reinforced Concrete Frame (Columns and Beams)



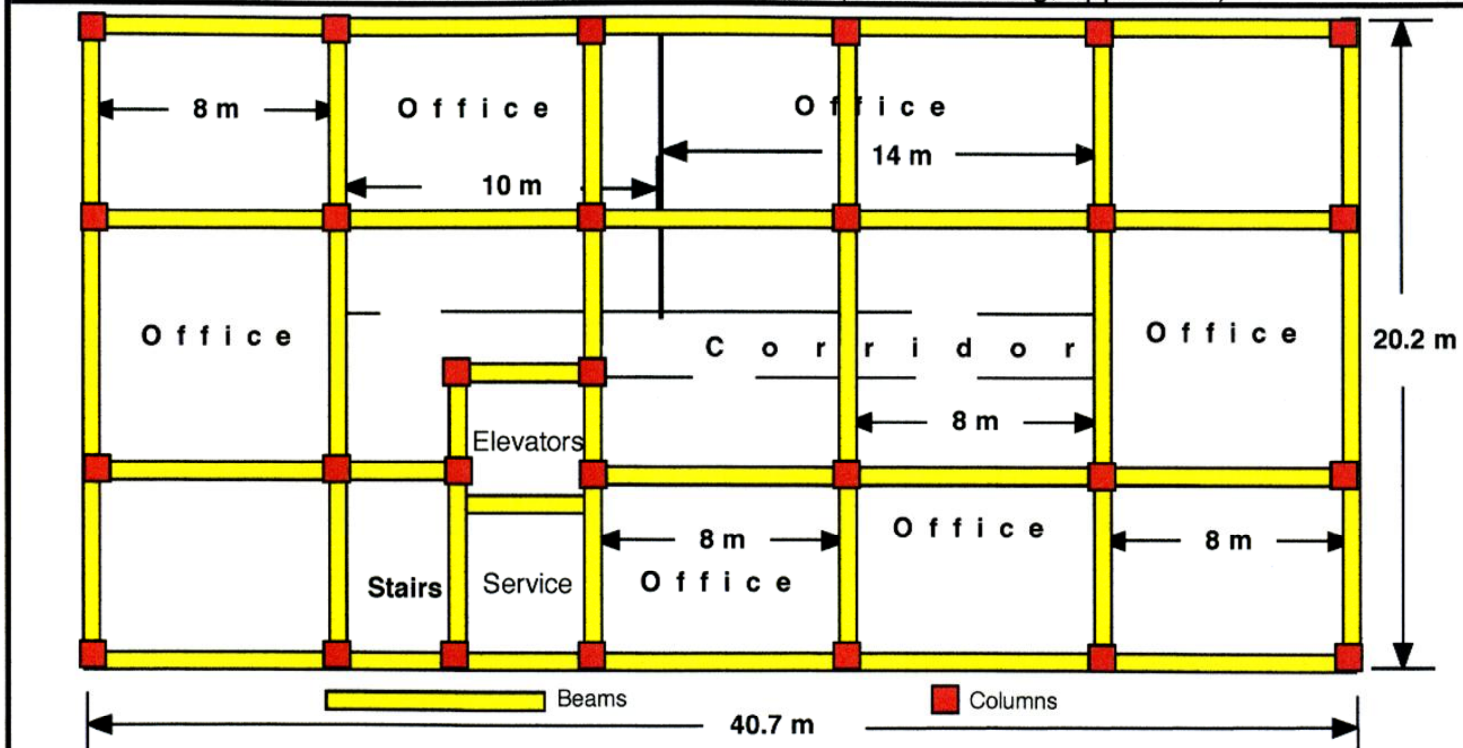
Commentary	All load (dead and live) is carried by steel reinforced concrete columns and beams (weight on reinforced concrete floors is transferred to the beams, and in turn transferred to the ground via the columns). The use of reinforcement permits spans between columns to be 8 meters (note: this span is greater than a traditional steel skeleton frame where spans are 4 or 5 meters). Four upper floors are 3 meters high: the ground floor (to house diverse functions) is 5 meters high.

Figure 207. Framed 10-4-a construction.

Framed 10-4-b Construction

R/C Framed Construction Office Building, Light Clad

Column and Beam construction (Office Building, upper floor)



Commentary	This planimetric view of reinforced concrete columns and beams of an office building floor. Columns are square, measuring 40 cm on a side. Beams are also square, 30 cm on a side. Connections are assumed to meet international standards. Interior partitions between and within the office units are non-load-bearing; the standard of using light weight studs (wood or metal) and general wall material (plywood, drywall, etc.). It is of importance to note that interior partitions do not necessarily match the structural columns and beams.

Figure 208. Framed 10-4-b construction.

Framed 11-1 Place on Building Construction Chart

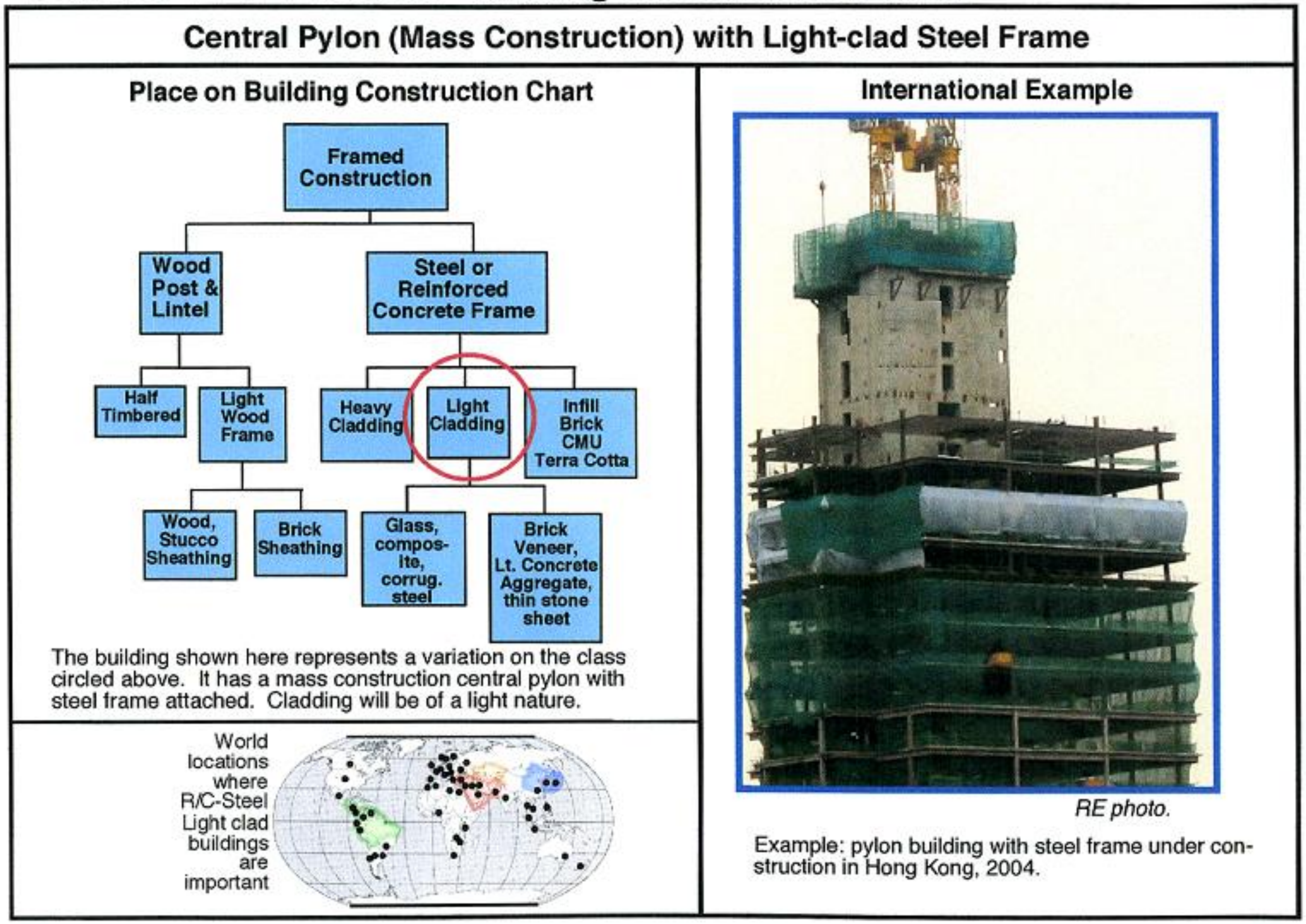
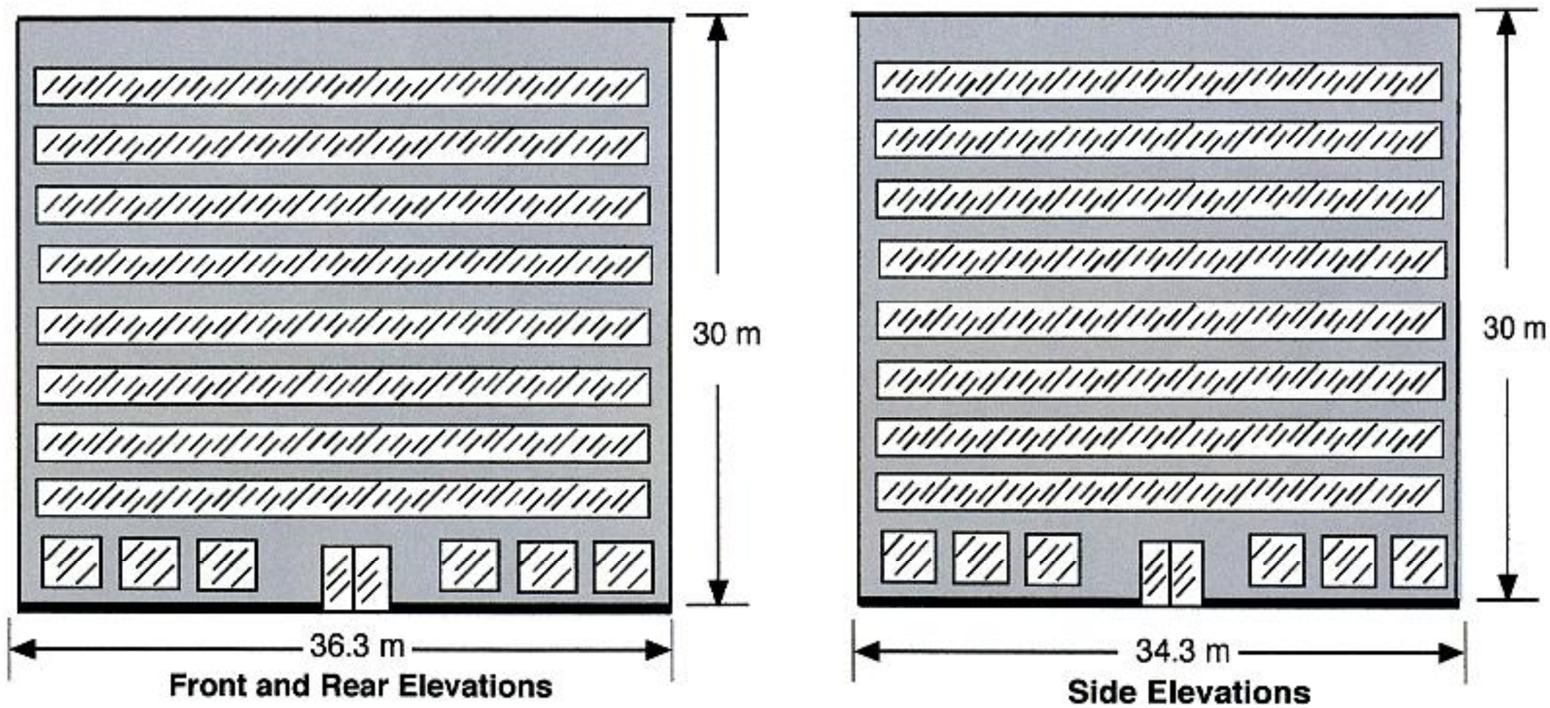


Figure 209. Framed 11-1 place on building construction chart.

Framed 11-2 Elevations

Central Pylon Office Building



Commentary This example of a framed, light-clad office building, with its broad spandrel window pattern, has a very high proportion of windows to wall (53.2 % on the front and rear elevations and 51.1 % for the side elevations); the average for all framed light-clad structures is 34.3 %. The large windows on the ground floor contribute to the high proportions.

Figure 210. Framed 11-2 elevations.

Framed 11-3-a Floor Plan

Central Pylon (Mass Construction) with Light-clad Steel Frame

Commentary

The big advantage of central pylon/steel frame construction is its provision of large, column-free spaces, ones ideal for today's large corporation offices. Lightweight partitions are easily moved to customize space; a single corporation may occupy an entire floor or all floors, allowing the building to become a corporate icon. Subdivision of interior space on each floor, if done, is achieved through use of cubicles; management level offices are often partitioned with access to windows. The ground floor serves as entry to the elevators and, generally, is used for building security personnel and display.

Elevators, stairs, and restrooms are located in the central pylon.

Floor Plan An Upper Floor

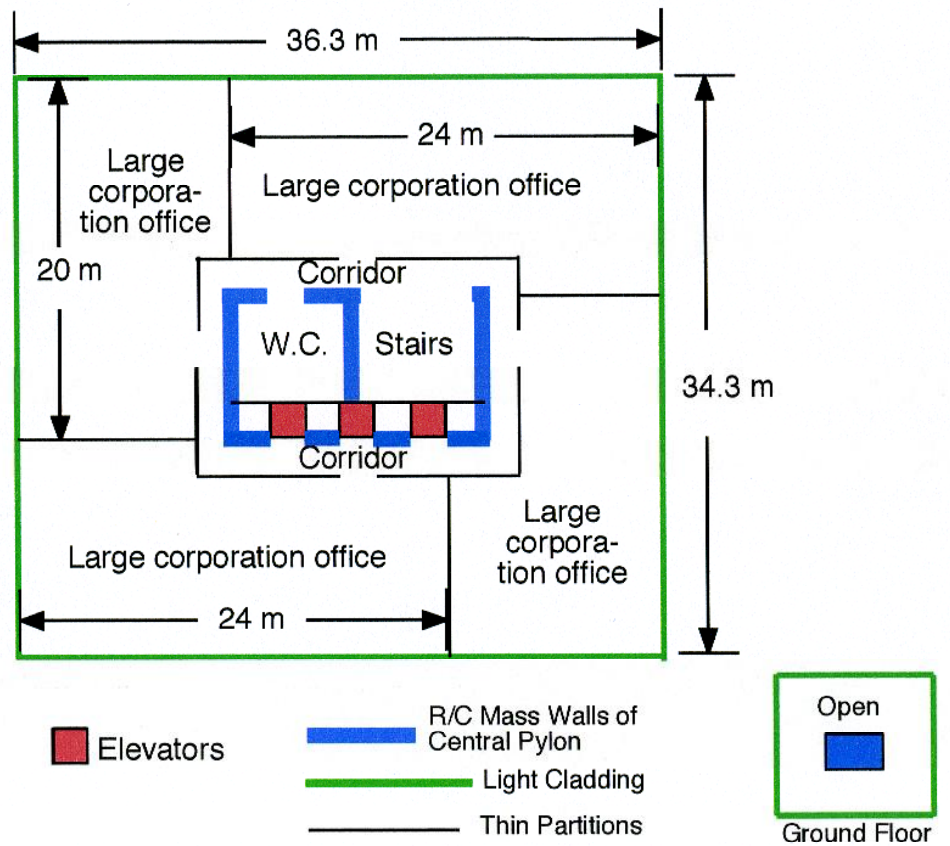


Figure 211. Framed 11-3-a floor plan.

Framed 11-4-a Construction

Central Pylon (Mass Construction) with Light-clad Steel Frame

Commentary

Central pylon/steel framed buildings form an example of both mass and framed construction in one structure. The reinforced concrete central pylon supports the steel frame members as the trunk of a tree supports its branches. It transfers loads from the beams of the steel frame to the ground. Walls of this central pylon are thick (usually about 30 cm) with rebar near the surfaces of both sides of each wall. It also serves as locale for services (elevators, stairways, W.C.s, and service modules). The long steel beams projecting outward from the central pylon enclose large spaces with but a sparse network of steel columns (far fewer than are seen in skeleton steel frame structures owing to the structural strength provided by the pylon).

Central Pylon and Steel Columns and Beams

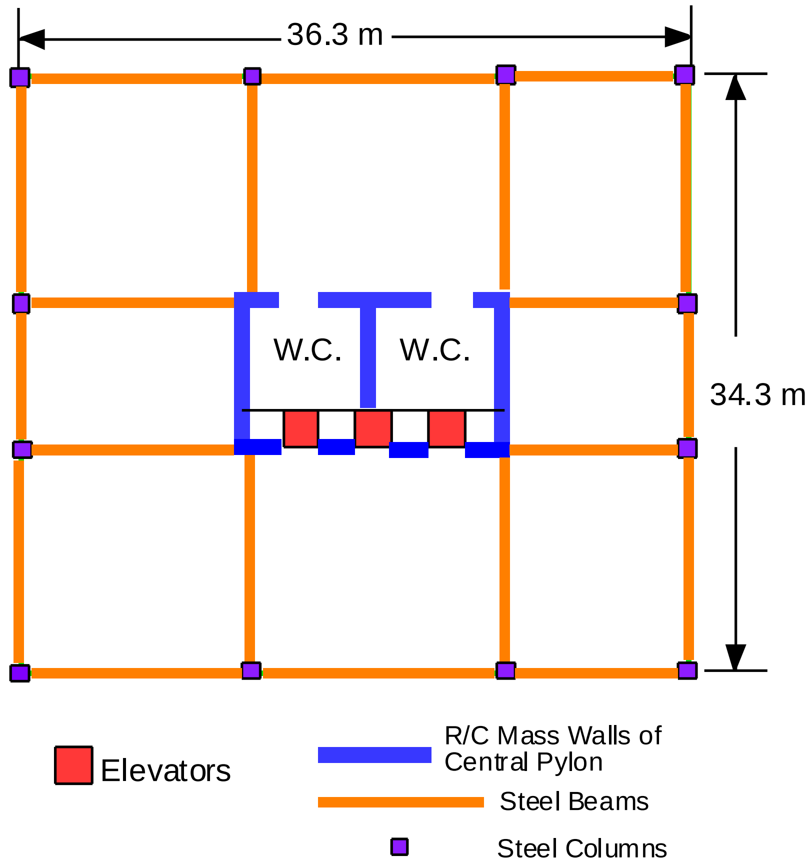


Figure 212. Framed 11-4-a construction.

Framed 11-4-b Construction

Central Pylon (Mass Construction) with Light-clad Steel Frame

Construction Process

Commentary

The anatomy of central pylon/steel frame construction is revealed in this demonstration of a building under construction. The common practice is to construct the central pylon first, using thick (30 cm) reinforced concrete walls to enclose elevators and service modules and to form an anchor for attaching steel beams. The construction process proceeds with the addition of the steel columns and beams. From the ground up, fireproofing is applied to the steel members. Cladding material and windows are then added. In this example, cladding and windows are finished about half way up the structure.

Central Pylon and Steel Columns and Beams Under Construction

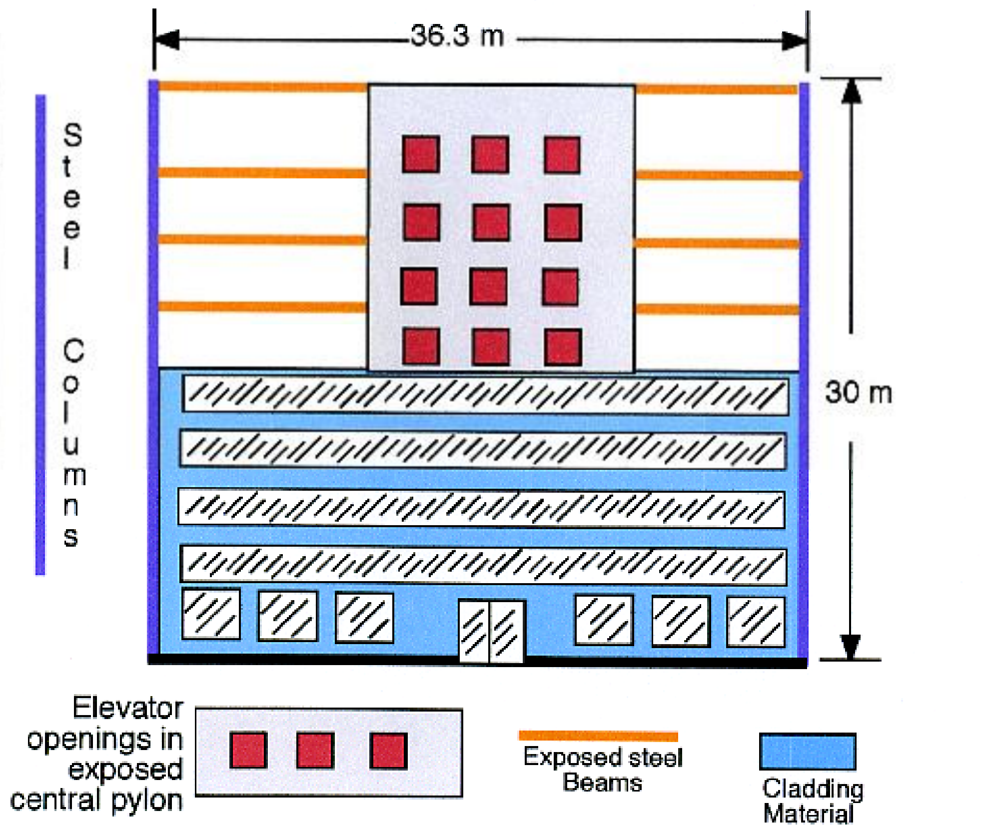


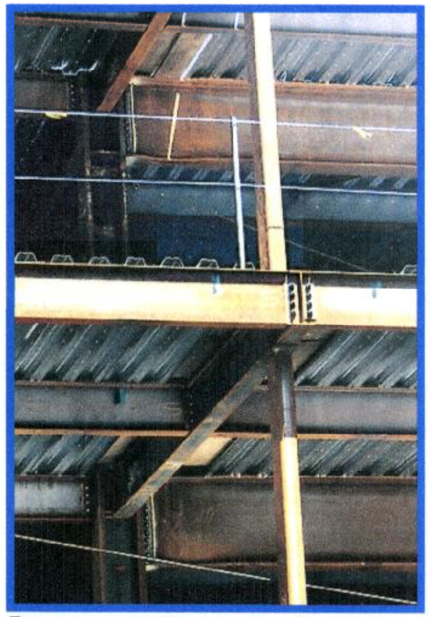
Figure 213. Framed 11-4-b construction.

Framed 11-4-c Construction

Central Pylon (Mass Construction) with Light-clad Steel Frame

Construction details: pylon, frame, and floors

Central pylon building under construction in Tel Aviv, 1999. *RE photo.*



Beam connections and column/beam connections. *RE photo*

Support for corrugated steel floor. *RE photo*

Commentary

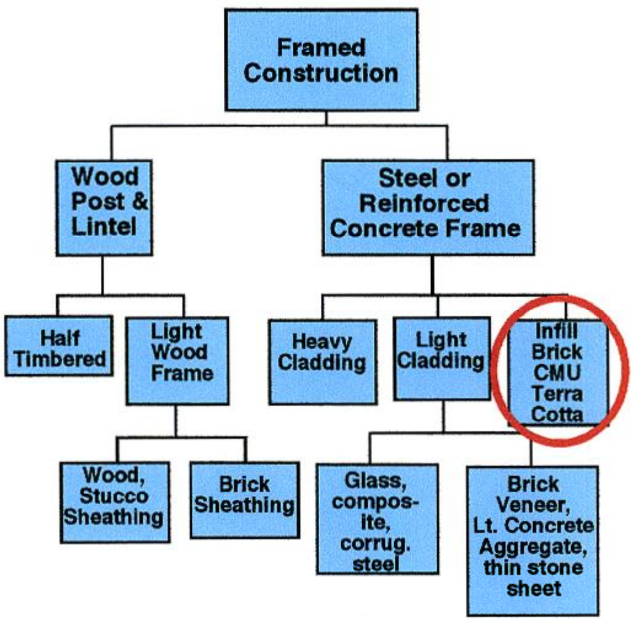
The central pylon building, to the left, shows pouring concrete into forms in the pylon, erection of the frame, and placement of cladding and windows. Connection details are seen in the center photo. Support for the corrugated steel floor is seen on the right.

Figure 214. Framed 11-4-c construction.

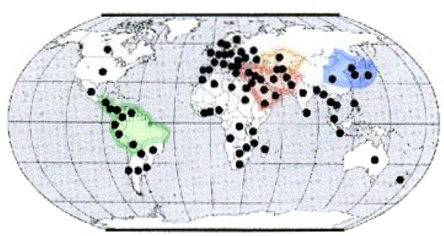
Framed 12-1 Place on Building Construction Chart

R/C Framed Construction House with Brick Infill Walls

Place on Building Construction Chart



World locations where R/C framed infill buildings are important



International Example

RE photo.

This unfinished structure, (near Luxor, Egypt, 2004), is typical of what is seen in much of the third world, a building under construction (and may have been so for some time). The rebar juts out of the columns possibly anticipating another floor later. Brick infill is double brick. The r/c beams and columns are crude and probably larger than necessary. Sub-standard concrete strength may be responsible.

Figure 215. Framed 12-1 place on building construction chart.

Framed 12-2-a Elevation

R/C Framed Construction House with Brick Infill Walls

Commentary

Non-load-bearing Brick infill walls between columns and beams is two bricks thick (23 cm).

Upon completion of building, bricks are commonly covered with a coating of stucco (usually about 2 to 3 cm thick).

Front Elevation
Brick Infill

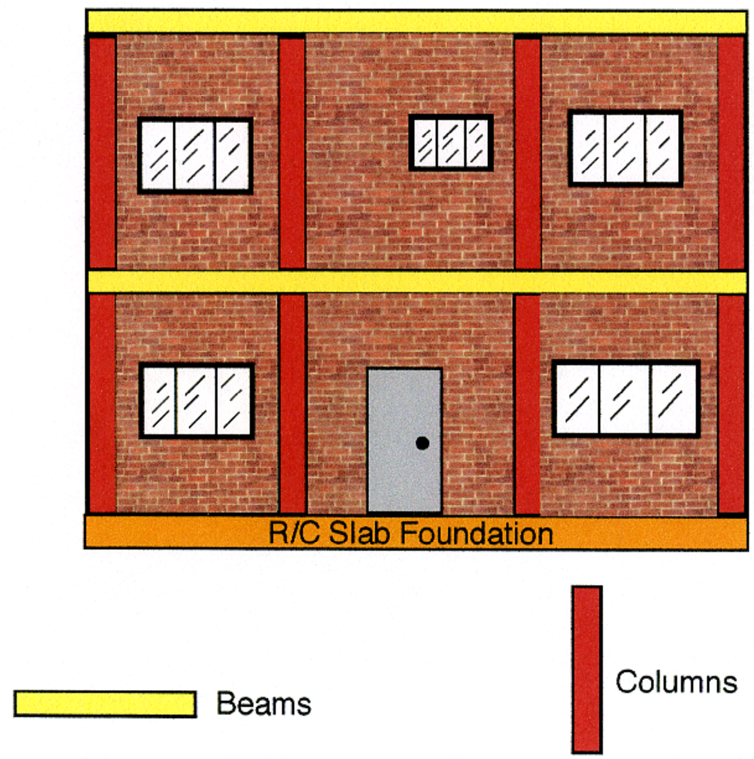


Figure 216. Framed 12-2-a elevation.

Framed 12-2-b   Elevation

R/C Framed Construction House with Brick Infill Walls

Commentary

Non-load-bearing Brick infill walls between columns and beams is two bricks thick (23 cm).

Upon completion of building, bricks are commonly covered with a coating of stucco (usually about 2 to 3 cm thick).

Side Elevation

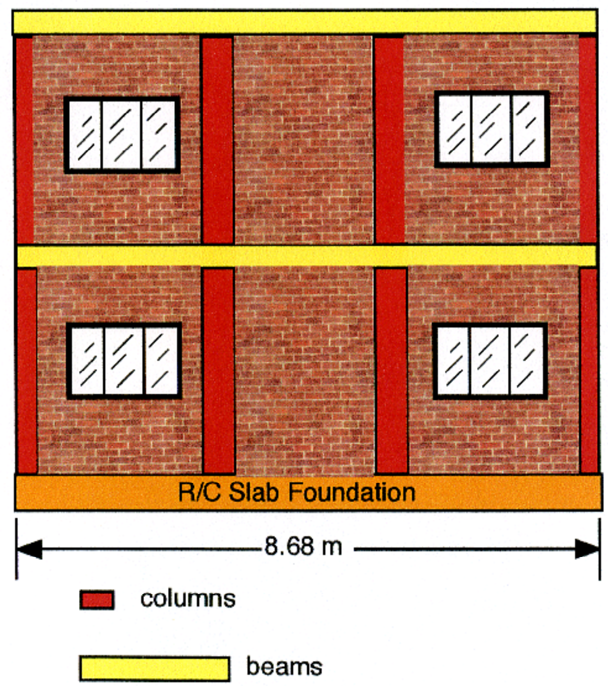


Figure 217. Framed 12-2-b elevation.

Framed 12-3-a Floor Plan

R/C Framed Construction House with Brick Infill Walls

Floor Plan (Ground floor of a 2 story house)

Commentary

While variations on the floor plan given here are infinite, this plan serves as a generic composite. It takes into consideration dimensions of rooms, corridor, doorways, and windows that have a human scale, based on standard sizes of furniture and living space needs.

This ground floor plan has rooms, in appropriate sizes, required to meet common daily needs: living and family eating areas are joined; the dining area can be served by the kitchen; utility needs are met by a small utility room; the kitchen is of modest but adequate size. Entry hall and stairway meet common needs.

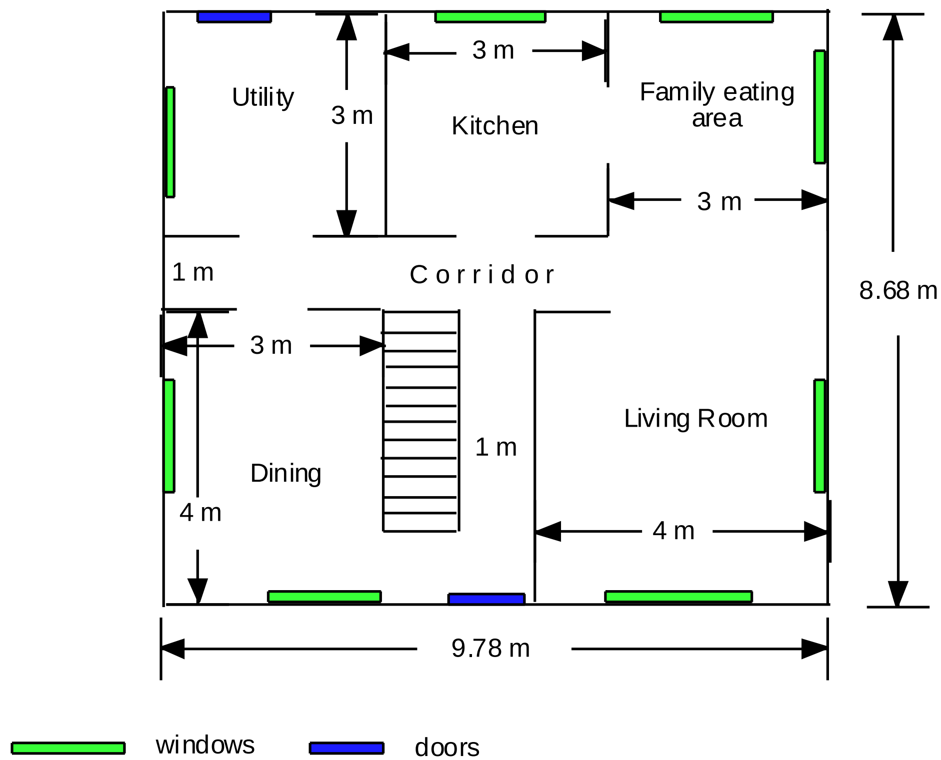


Figure 218. Framed 12-3-a floor plan.

Framed 12-3-b Floor Plan

R/C Framed Construction House with Brick Infill Walls

Floor Plans (upper floor of 2 story house)

Commentary

While variations on the floor plan given here are infinite, this plan serves as a generic composite. It takes into consideration dimensions of rooms, corridor, doorways, and windows that are dictated by a human scale, based on standard sizes of furniture (e.g., 2 meter long beds, and bathroom fixtures). For instance, a 3 m by 3 m room is just barely large enough to accommodate a double bed and furniture. Larger bedrooms (e.g., a 4 by 5 m master bedroom) express a size desired by home owners.

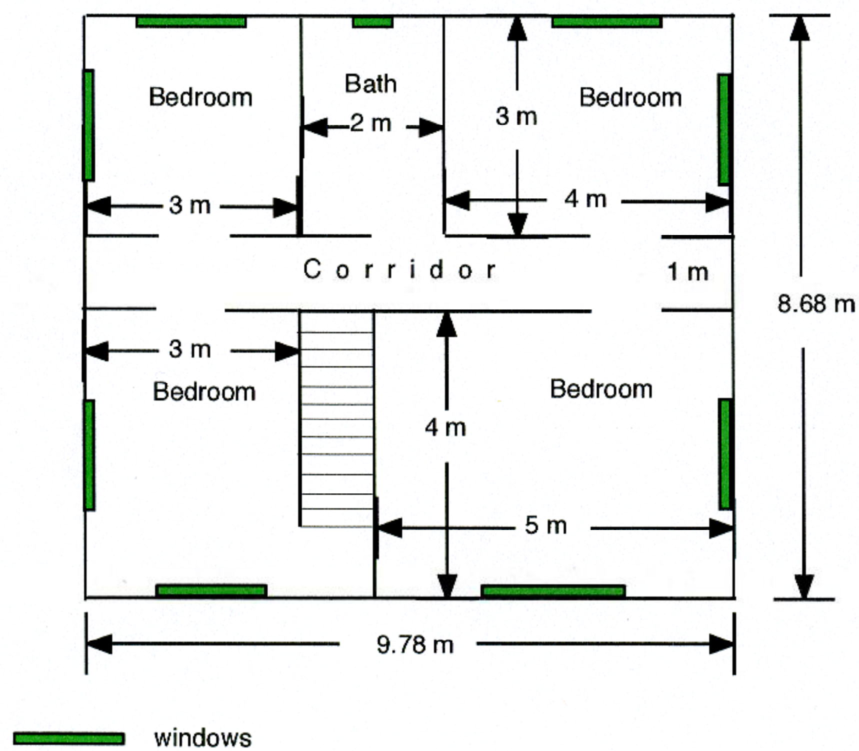


Figure 219. Framed 12-3-b floor plan.

Framed 12-4-a Construction

R/C Framed Construction House with Brick Infill Walls

Commentary

This front elevation view of the ground floor of a reinforced concrete framed house shows the arrangement of the r/c columns and beams.

Columns measure 25 cm by 40 cm. The wide side of the beams are parallel with the face of the exterior walls.

Beams are square, measuring 30 cm by 30 cm. In the construction process, poured concrete beams are placed on the columns extending upward from the ground floor. The process in then repeated for upper floors.

R/C floors are connected to the beams with tied rebar.

Front Elevation

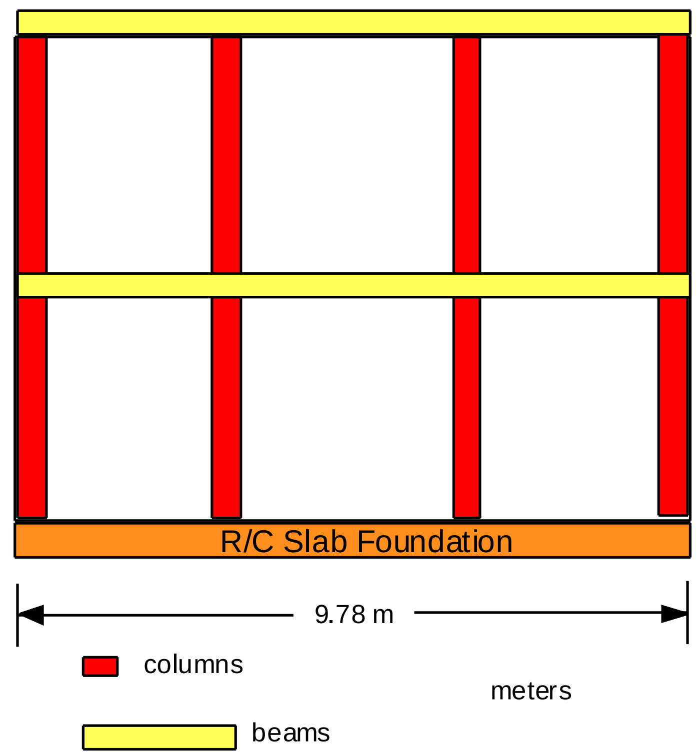


Figure 220. Framed 12-4-a construction.

Framed 12-4-b Construction

R/C Framed Construction House with Brick Infill Walls

Commentary

This side elevation view of the ground floor of a reinforced concrete framed house shows the arrangement of the r/c columns and beams.

Columns measure 25 cm by 40 cm. The wide side of the beams are parallel with the face of the exterior walls.

Beams are square, measuring 30 cm by 30 cm.

R/C floors are connected to the beams with tied rebar.

Side Elevation

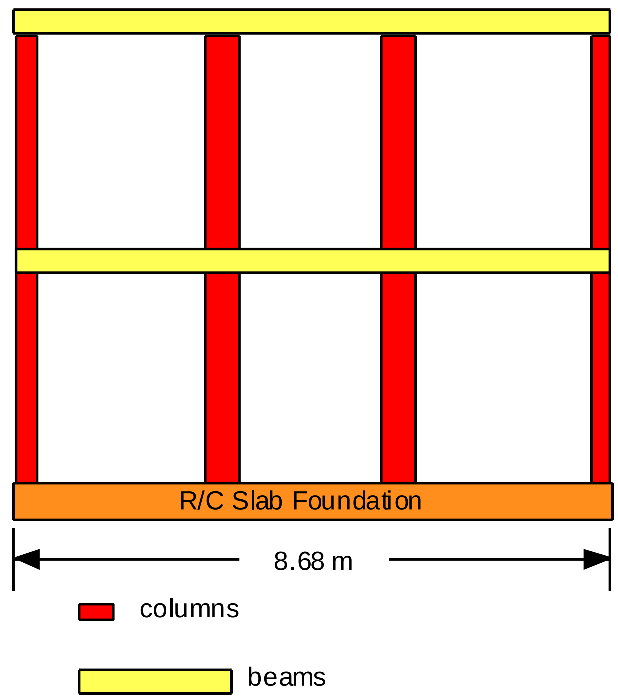


Figure 221. Framed 12-4-b construction.

Framed 12-4-c Construction

R/C Framed Construction House with Brick Infill Walls

Column and Beam construction (Ground floor of a 2 story house)

Commentary

This planimetric view of the ground floor of a reinforced concrete framed house (with various infill material) shows the arrangement of the r/c columns and beams.

Columns measure 25 cm by 40 cm. The wide side of the beams are parallel with the face of the exterior walls.

Beams are square, measuring 30 cm by 30 cm.

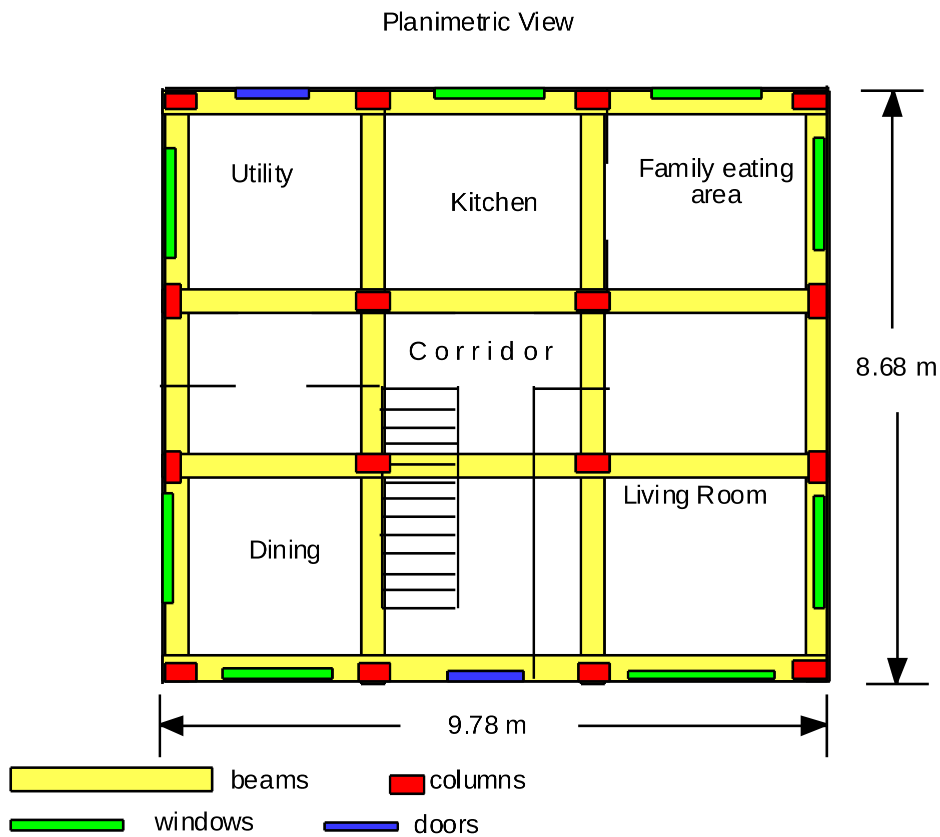


Figure 222. Framed 12-4-c construction.

Framed 12-4-d Construction

R/C Framed Construction House with Brick Infill Walls

Column and Beam construction (upstairs floor of 2 story house)

Commentary

This planimetric view of the upstairs floor of a reinforced concrete framed house (with various infill material) shows the arrangement of the r/c columns and beams.

Columns measure 25 cm by 40 cm. The wide side of the columns is parallel with the face of the exterior walls.

Beams are square, measuring 30 cm by 30 cm.

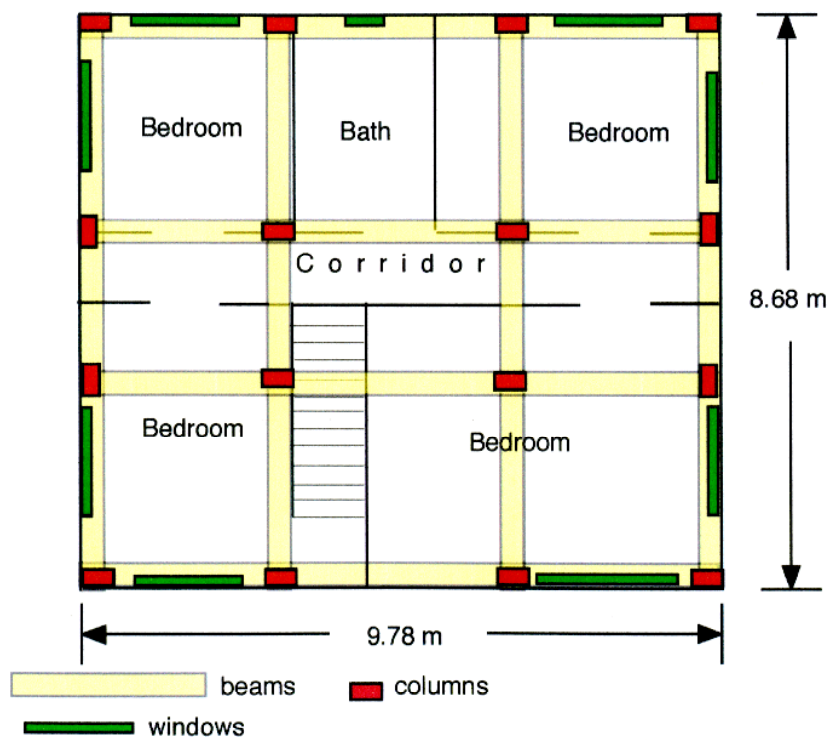
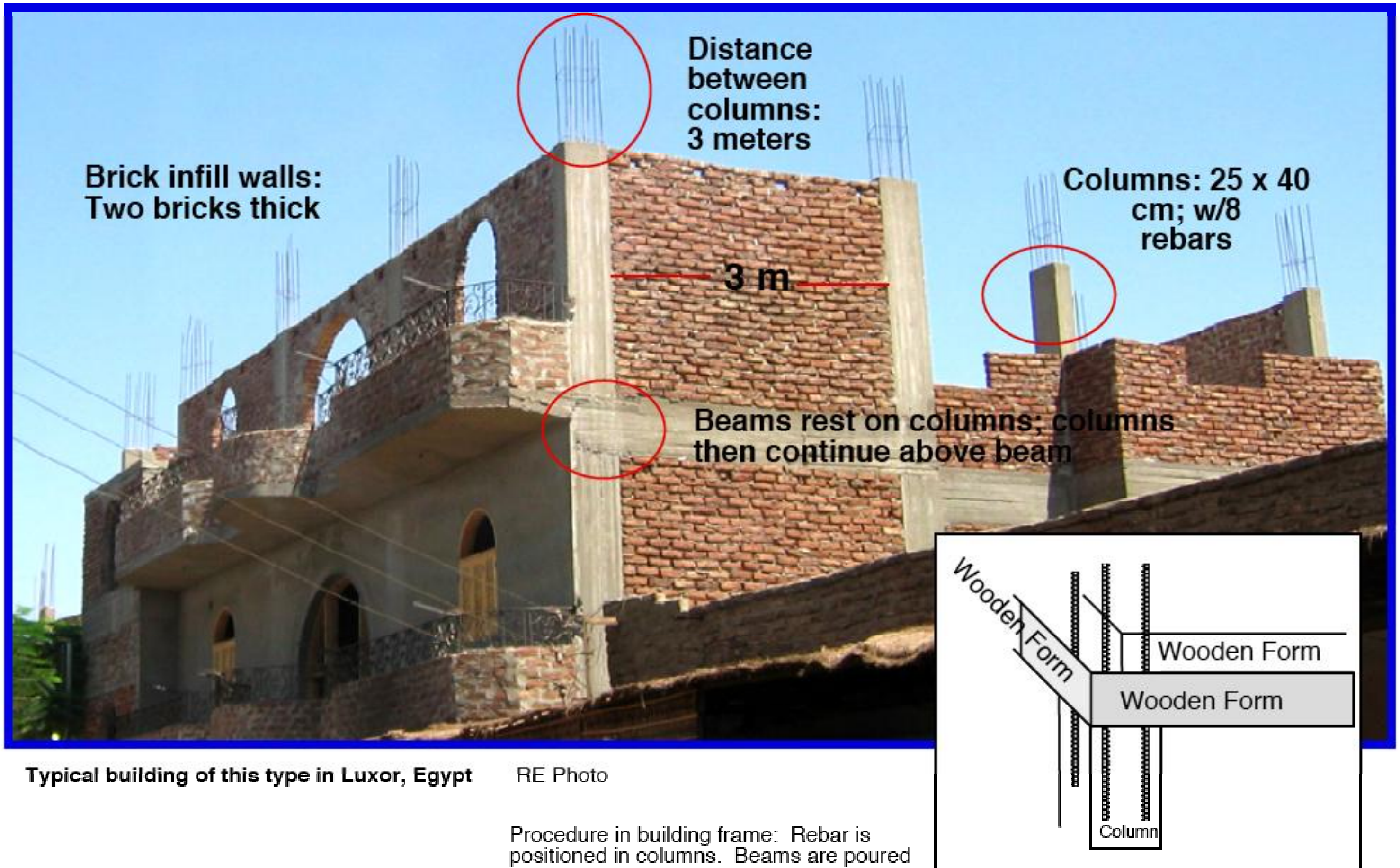


Figure 223. Framed 12-4-d construction.

Framed 12-4-e Construction

Construction details of a Reinforced Concrete framed house with brick (non-load-bearing) infill walls



Typical building of this type in Luxor, Egypt RE Photo

Procedure in building frame: Rebar is positioned in columns. Beams are poured around rebar in form and rest on column. Process is repeated with each new story.

Figure 224. Framed 12-4-e construction.

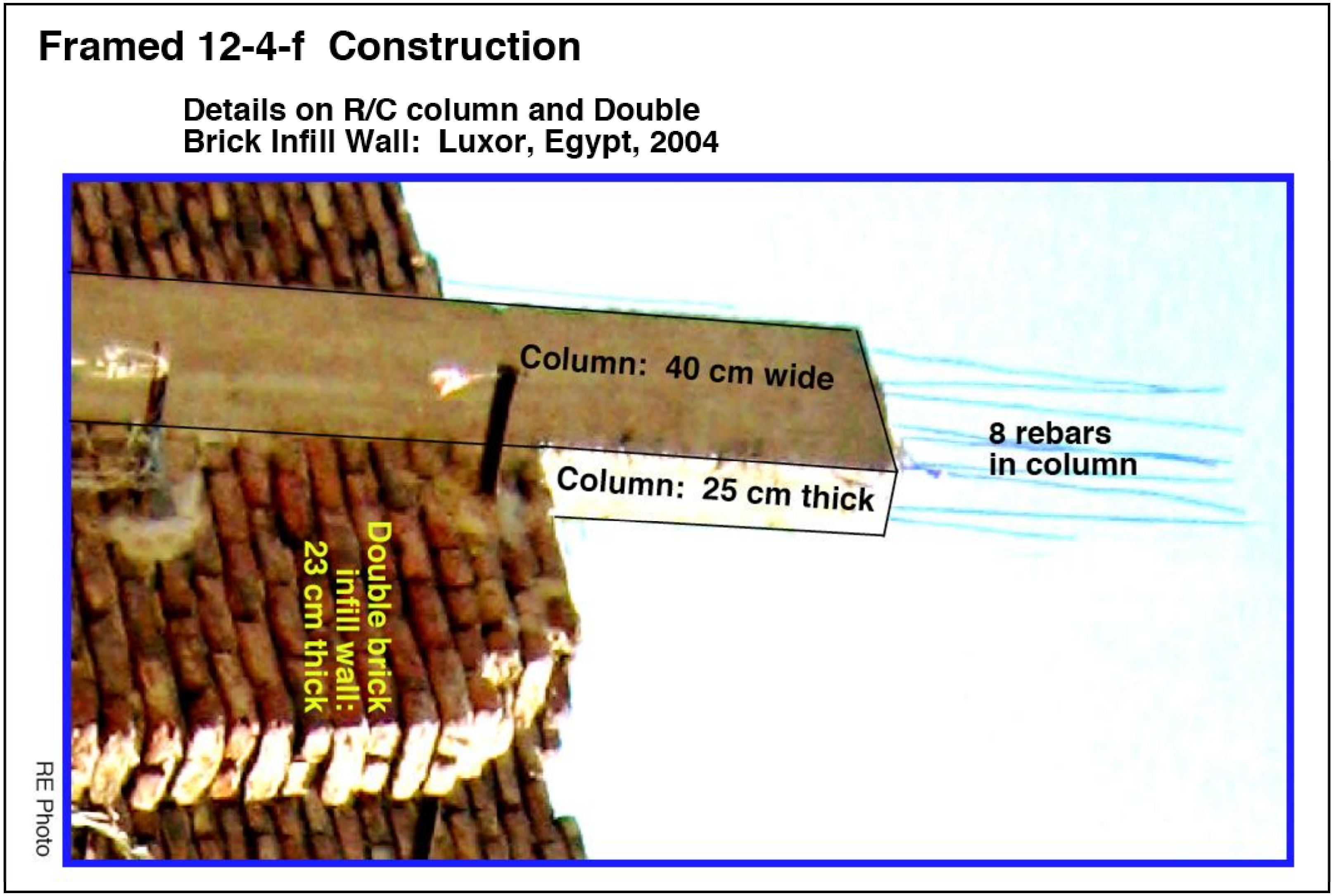
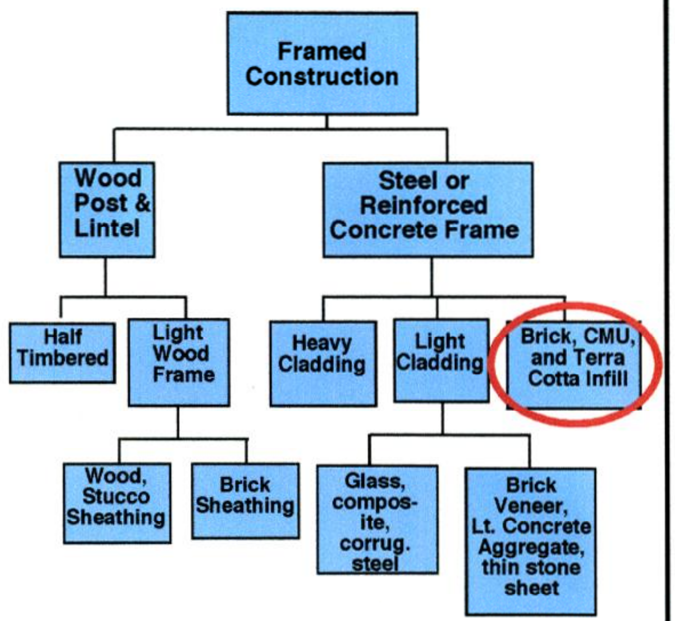


Figure 225. Framed 12-4-f construction.

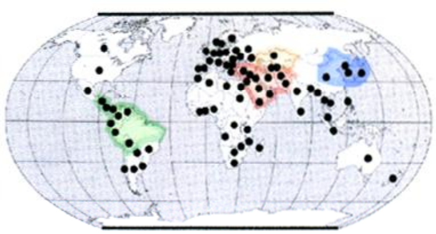
Framed 13-1 Place on Building Construction Chart

R/C Framed House with Terra Cotta Infill

Place on Building Construction Chart



World locations where R/C framed infill buildings are important



International Example

RE Photo

A house in Tunis, Tunisia, under construction being built with a reinforced concrete frame with terra cotta infill walls. This is a very common practice throughout much of the third world and is seen in Eastern Europe. The flat roof of the house is common in such dry areas as here in North Africa.

Figure 226. Framed 13-1 place on building construction chart.

Framed 13-2-a Elevation

R/C Framed House with Terra Cotta Infill

Commentary

Non-load-bearing Terra Cotta infill walls between columns and beams is one terra cotta block thick. (Terra cotta blocks measure 40 cm by 25 cm x 25 cm).

Upon completion of building, terra cotta blocks are commonly covered with a coating of stucco (usually about 2 to 3 cm thick).

Front Elevation
Terra Cotta Block Infill

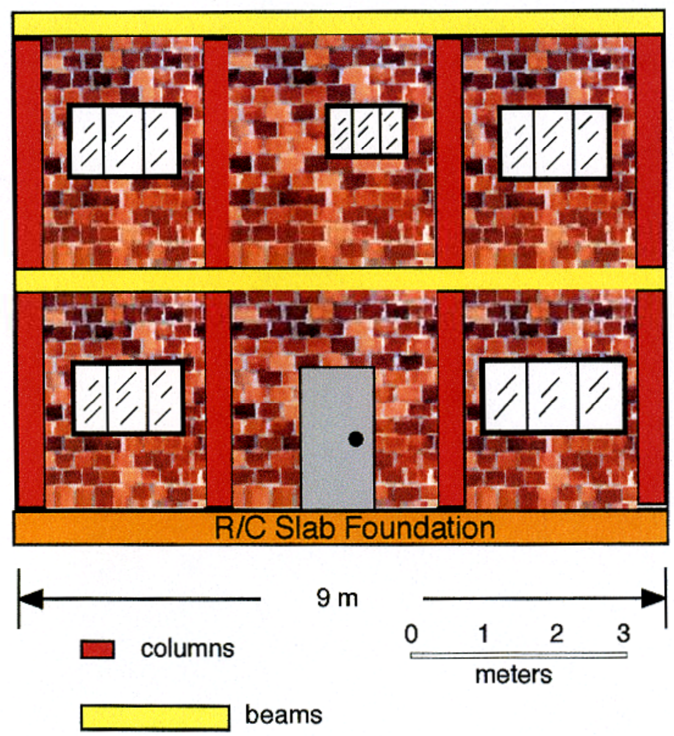


Figure 227. Framed 13-2-a elevation.

Framed 13-2-b Elevation

R/C Framed House with Terra Cotta Infill

Commentary

Non-load-bearing Terra Cotta infill walls between columns and beams is one terra cotta block thick. (Terra cotta blocks measure 40 cm by 25 cm x 25 cm).

Upon completion of building, terra cotta blocks are commonly covered with a coating of stucco (usually about 2 to 3 cm thick).

Side Elevation
Terra Cotta Block Infill

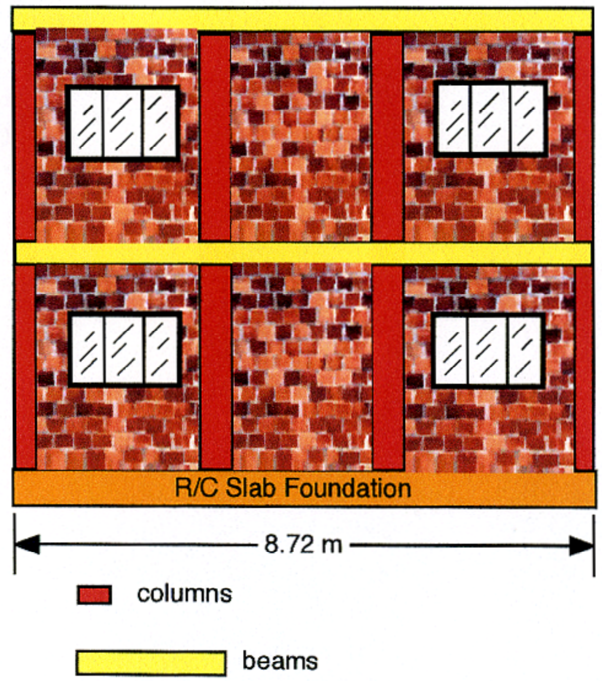


Figure 228. Framed 13-2-b elevation.

Framed 13-3-a Floor Plan

R/C Framed House with Terra Cotta Infill

Floor Plan (Ground floor of a 2 story house)

Commentary

While variations on the floor plan given here are infinite, this plan serves as a generic composite. It takes into consideration dimensions of rooms, corridor, doorways, and windows that have a human scale, based on standard sizes of furniture and living space needs.

This ground floor plan has rooms, in appropriate sizes, required to meet common daily needs: living and family eating areas are joined; the dining area can be served by the kitchen; utility needs are met by a small utility room; the kitchen is of modest but adequate size. Entry hall and stairway meet common needs.

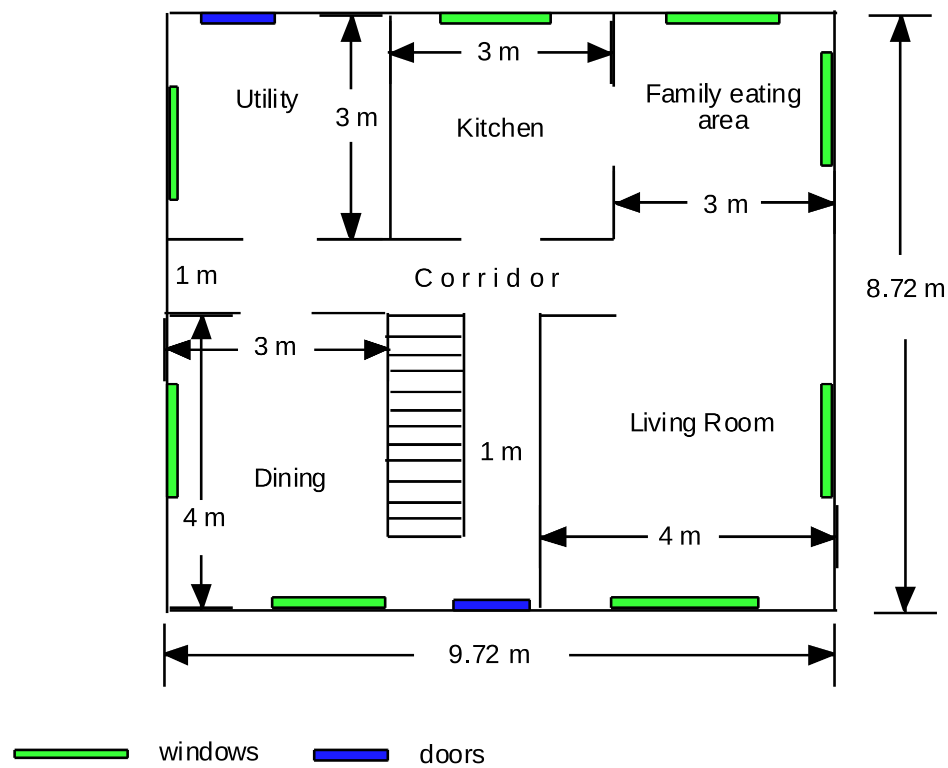


Figure 229. Framed 13-3-a floor plan.

Framed 13-3-b Floor Plan

R/C Framed House with Terra Cotta Infill

Floor Plans (upstairs floor of 2 story house)

Commentary

While variations on the floor plan given here are infinite, this plan serves as a generic composite. It takes into consideration dimensions of rooms, corridor, doorways, and windows that are dictated by a human scale, based on standard sizes of furniture (e.g., 2 meter long beds, and bathroom fixtures). For instance, a 3 m by 3 m room is just barely large enough to accommodate a double bed and furniture. Larger bedrooms (e.g., a 4 by 5 m master bedroom) express a size desired by home owners.

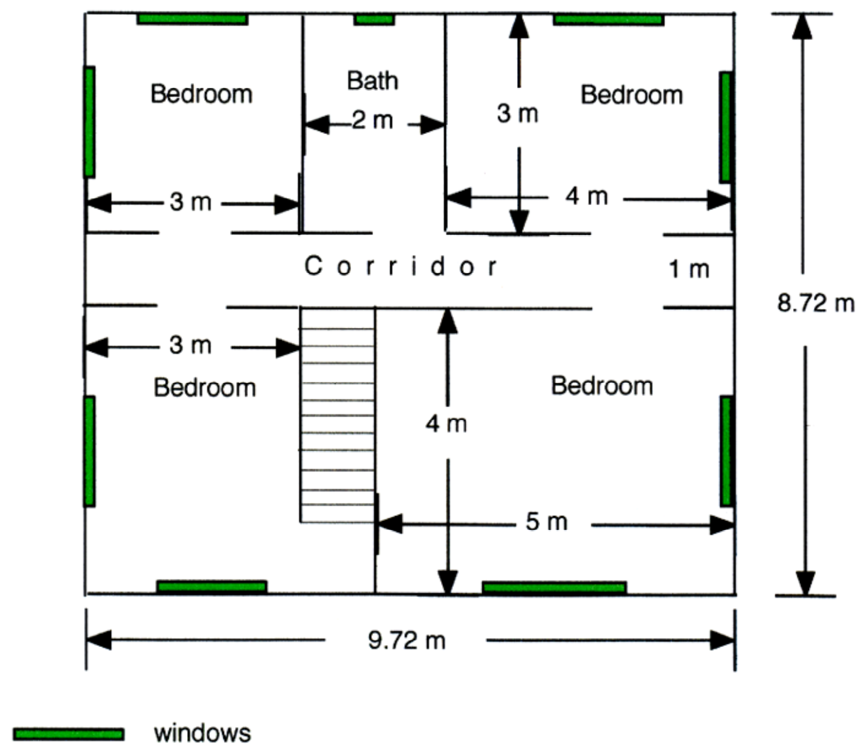


Figure 230. Framed 13-3-b floor plan.

Framed 13-4-a Construction

R/C Framed House with Terra Cotta Infill

Column and Beam construction (Ground floor of a 2 story house)

Commentary

This planimetric view of the ground floor of a reinforced concrete framed house (with terra cotta infill material) shows the arrangement of the r/c columns and beams.

Columns measure 25 cm by 40 cm. The wide side of the beams are parallel with the face of the exterior walls.

Beams are square, measuring 30 cm by 30 cm.

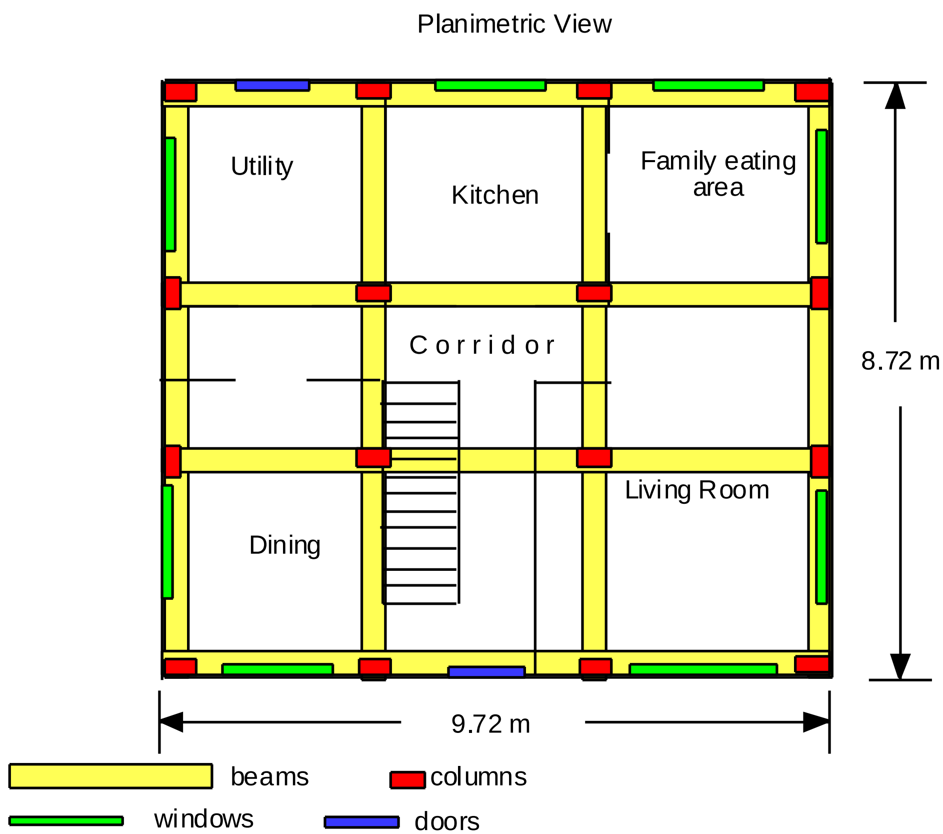


Figure 231. Framed 13-4-a construction.

Framed 13-4-b Construction

R/C Framed House with Terra Cotta Infill

Column and Beam construction (upstairs floor of 2 story house)

Commentary

This planimetric view of the upstairs floor of a reinforced concrete framed house (with various infill material) shows the arrangement of the r/c columns and beams.

Columns measure 25 cm by 40 cm. The wide side of the columns are parallel with the face of the exterior walls.

Beams are square, measuring 30 cm by 30 cm.

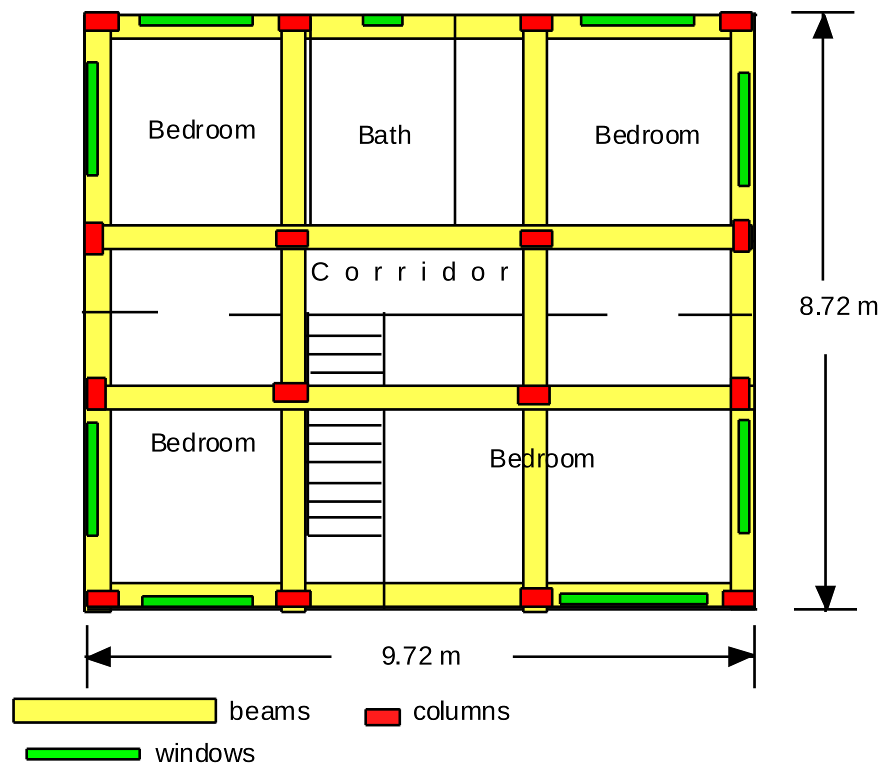


Figure 232. Framed 13-4-b construction.

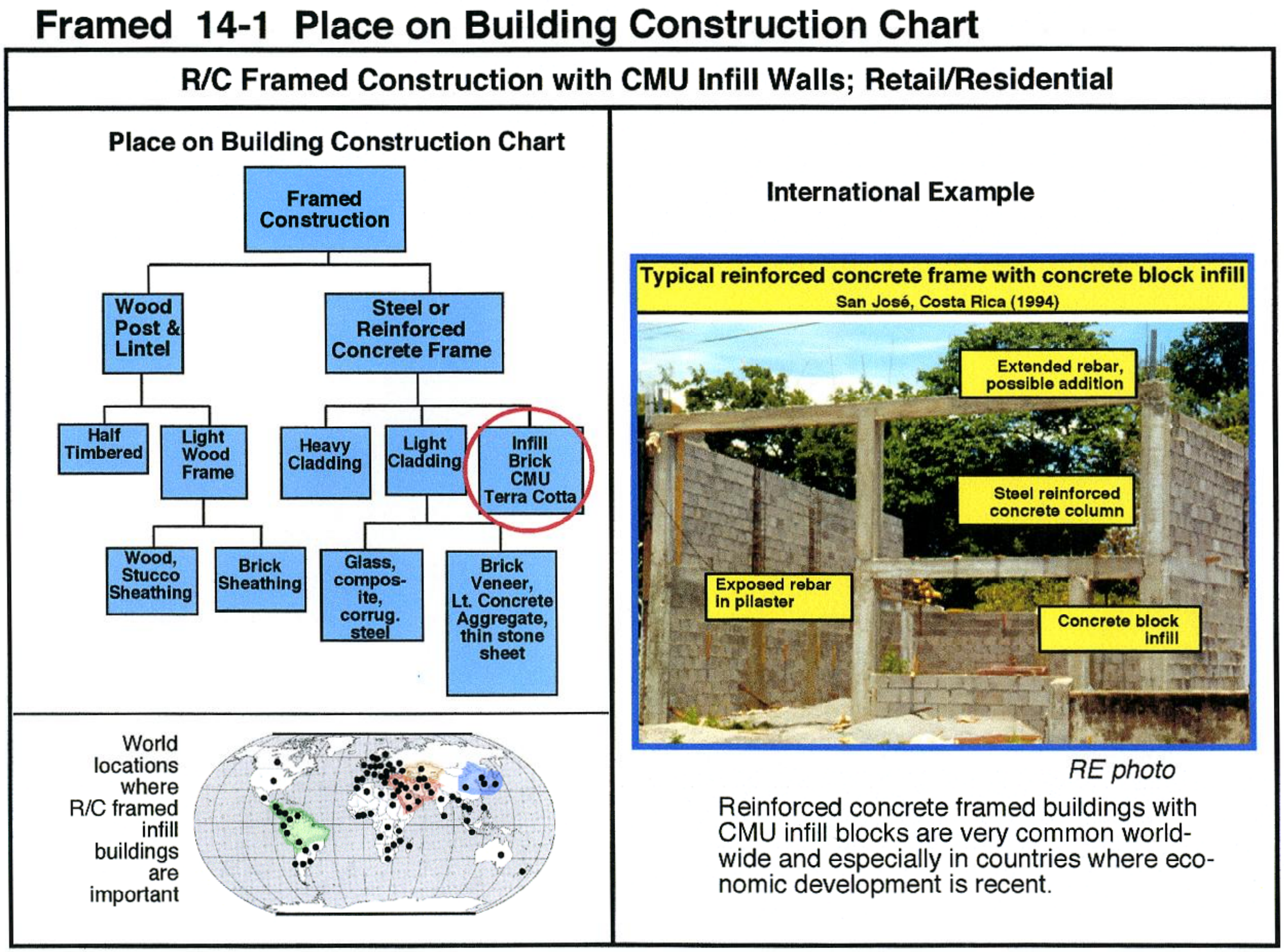


Figure 233. Framed 14-1 place on building construction chart.

Framed 14-2-a Elevation

R/C Framed Construction with CMU Infill Walls; Retail/Residential

Construction Method and Dimensions

Commentary

This front elevation shows the different venting (windows and door) for the two floors; the retail store on the ground floor has large display windows and a central door. The residence above has typical smaller windows; the entrance to the unit is at the rear.

Concrete frame members, columns and beams appear in red. An example of the CMU infill blocks is seen on the ground floor. CMU blocks, in finished buildings, are ordinarily covered by stucco to protect them from the elements.

Front Elevation

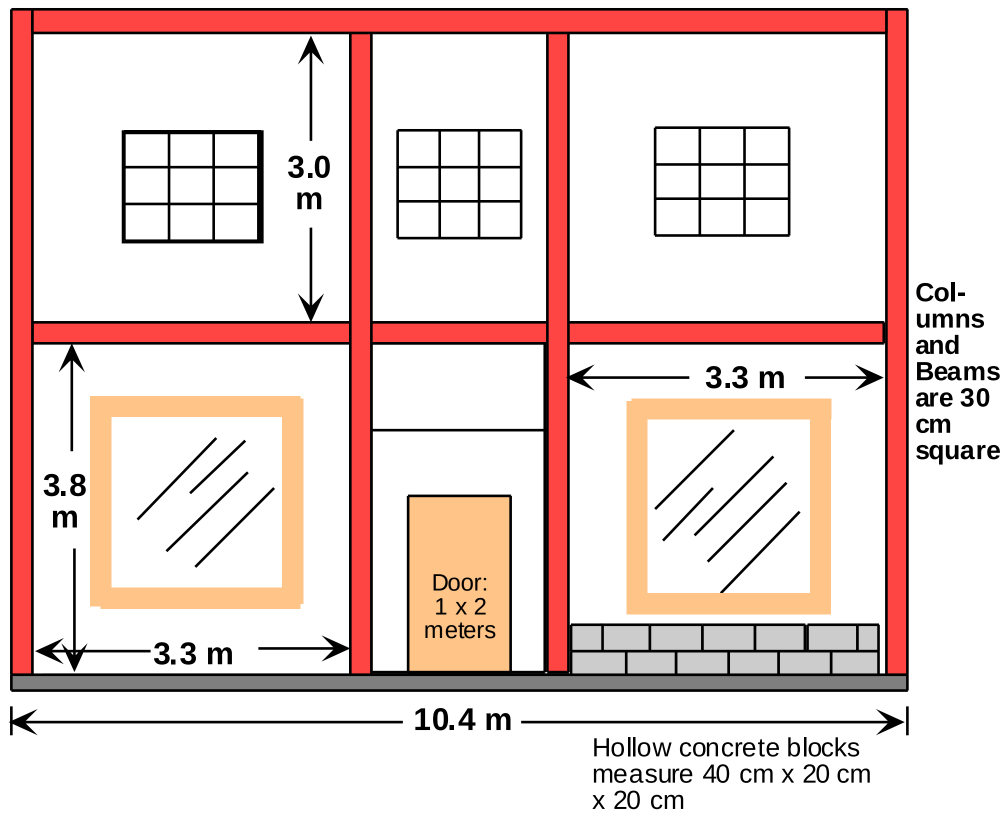


Figure 234. Framed 14-2-a elevation.

Framed 14-2-b Elevation

R/C Framed Construction with CMU Infill Walls; Retail/Residential

Construction Method and Dimensions

Commentary

Venting of the rear elevation shows a service door for the rear of the retail store on the ground floor. The upper floor has two windows and the entrance door to the residential unit; a stairway to the upper floor is not shown.

Part of the CMU blocks are exposed.

Rear Elevation

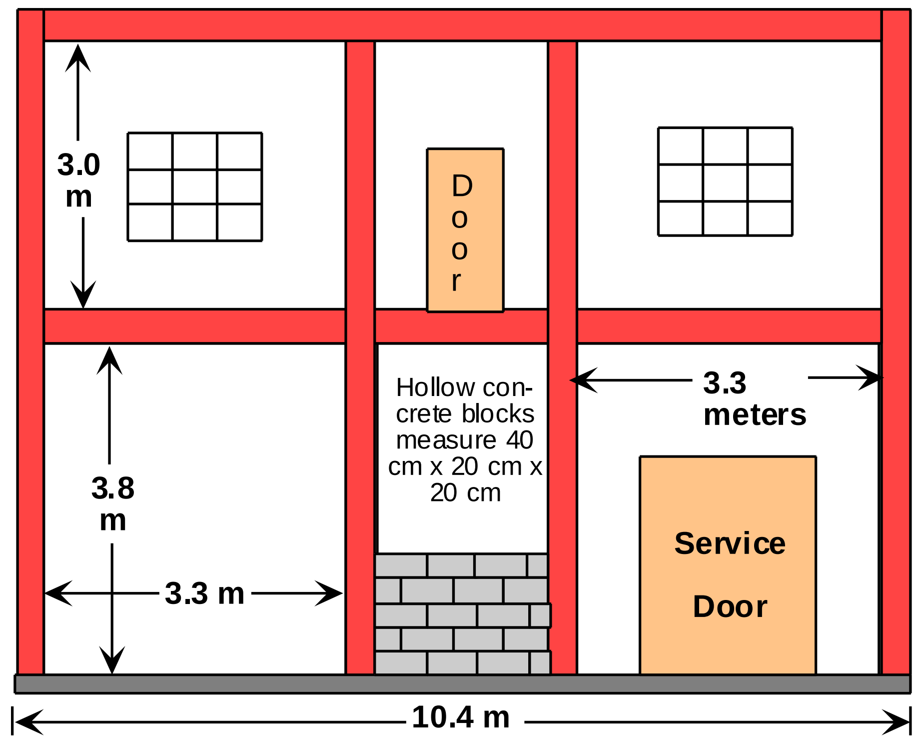


Figure 235. Framed 14-2-b elevation.

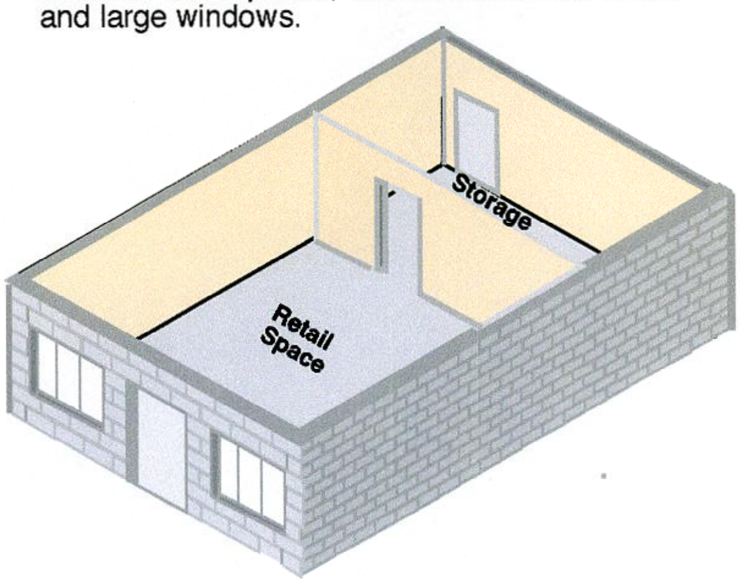
Framed 14-3-a Floor Plan

R/C Framed Construction with CMU Infill Walls; Retail/Residential

Floor Plan and Isometric: Ground Floor (Retail)

Commentary

Ground level retail establishments, such as shown here, will normally be longer than they are wide, and will have space devoted to inventory storage and other business functions in the rear of the building, and will have a wide access door. Retail space will be without partitions, although columns are exposed, and will have wide doors and large windows.



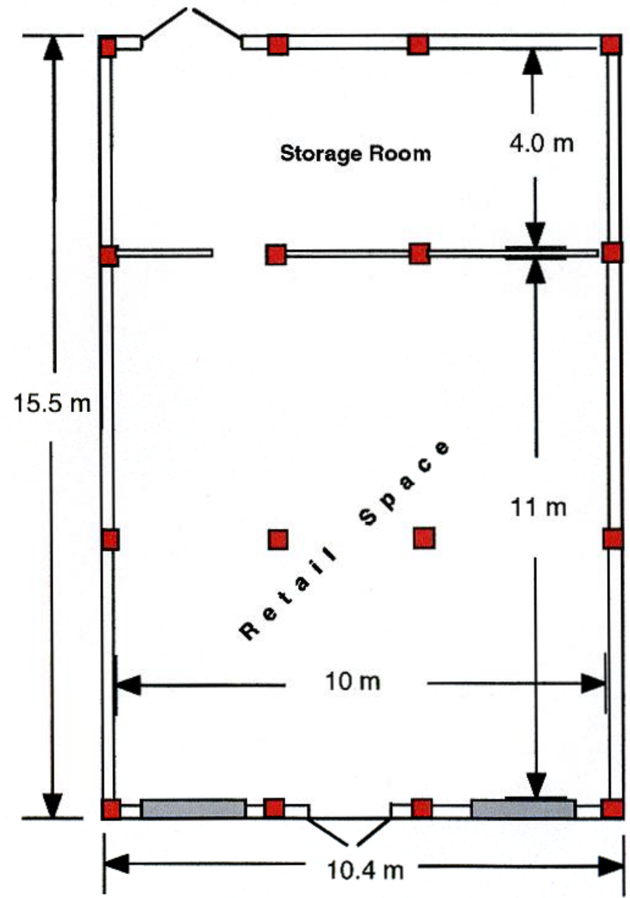


Figure 236. Framed 14-3-a floor plan.

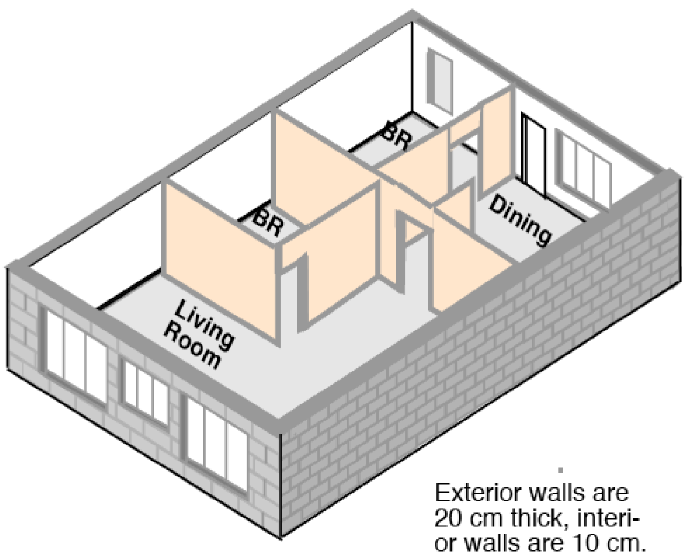
Framed 14-3-b Floor Plan

R/C Framed Construction with CMU Infill Walls; Retail/Residential

Floor Plan and Isometric: Upper Floor (Residential)

Commentary

Residential floor is divided into rooms by partitions one 10 cm CMU block thick. Windows are only on front and rear faces, as is typical of such long rectangle footprints. Answering concerns about collateral damage, the unit shown here would house a family of four.



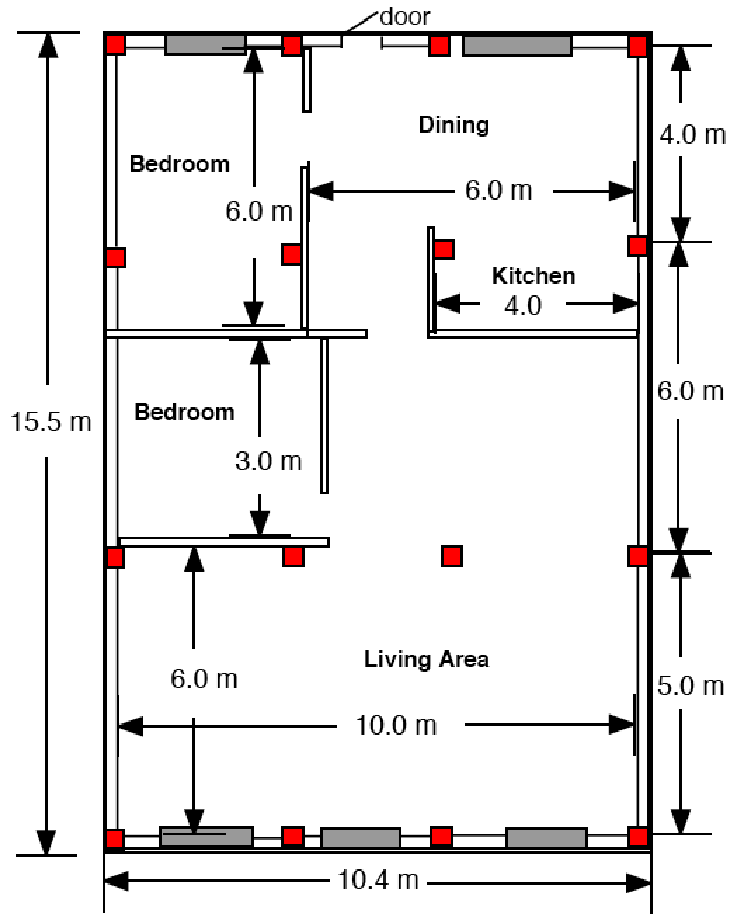


Figure 237. Framed 14-3-b floor plan.

Framed 14-4-a Construction

R/C Framed Construction with CMU Infill Walls; Retail/Residential

Construction Method and Dimensions

Commentary

Loads, in this two story example, are borne by the reinforced concrete columns and beams. Amount of rebar and strength of concrete varies with: height of building; potential earthquake mitigation; economic level of the country in which building is located; quality of materials; local building codes; and adherence to those codes by contractors and inspectors.

Structures are built on concrete platforms, and have web reinforced concrete roofs, and floor/ceilings between stories.

Strength of columns:
305 kg/cm^2

Strength of floor/ceilings:
255 kg/cm^2

Frame

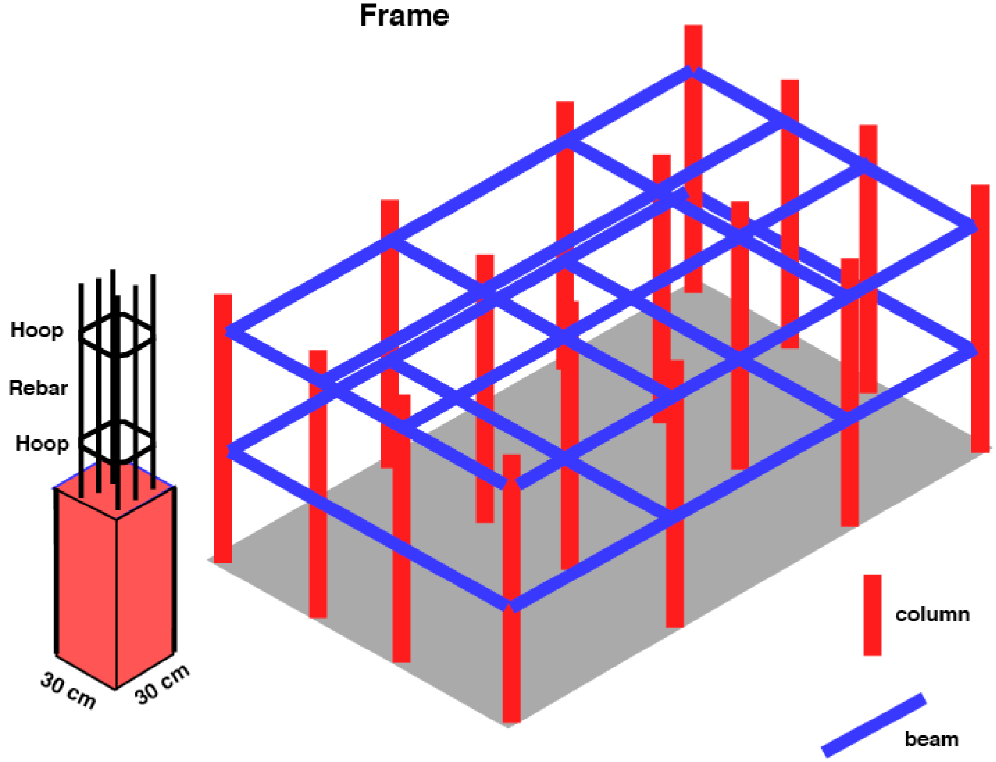


Figure 238. Framed 14-4-a construction.

Framed 14-4-b Construction

R/C Framed Construction with CMU Infill Walls; Retail/Residential

Construction Method and Dimensions

Commentary

This isometric (45°) view shows the upper residential floor exposed, venting, and the exposed CMU blocks on both front and side.

CMU strength:
152 kg/cm^2

Isometric view

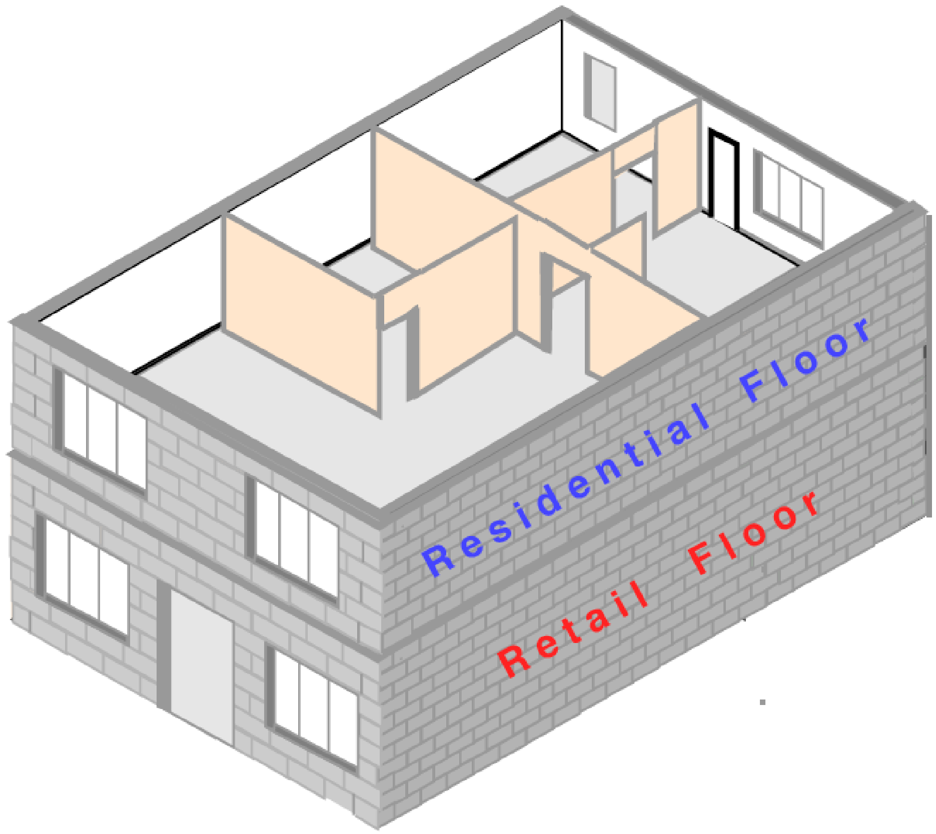


Figure 239. Framed 14-4-b construction.

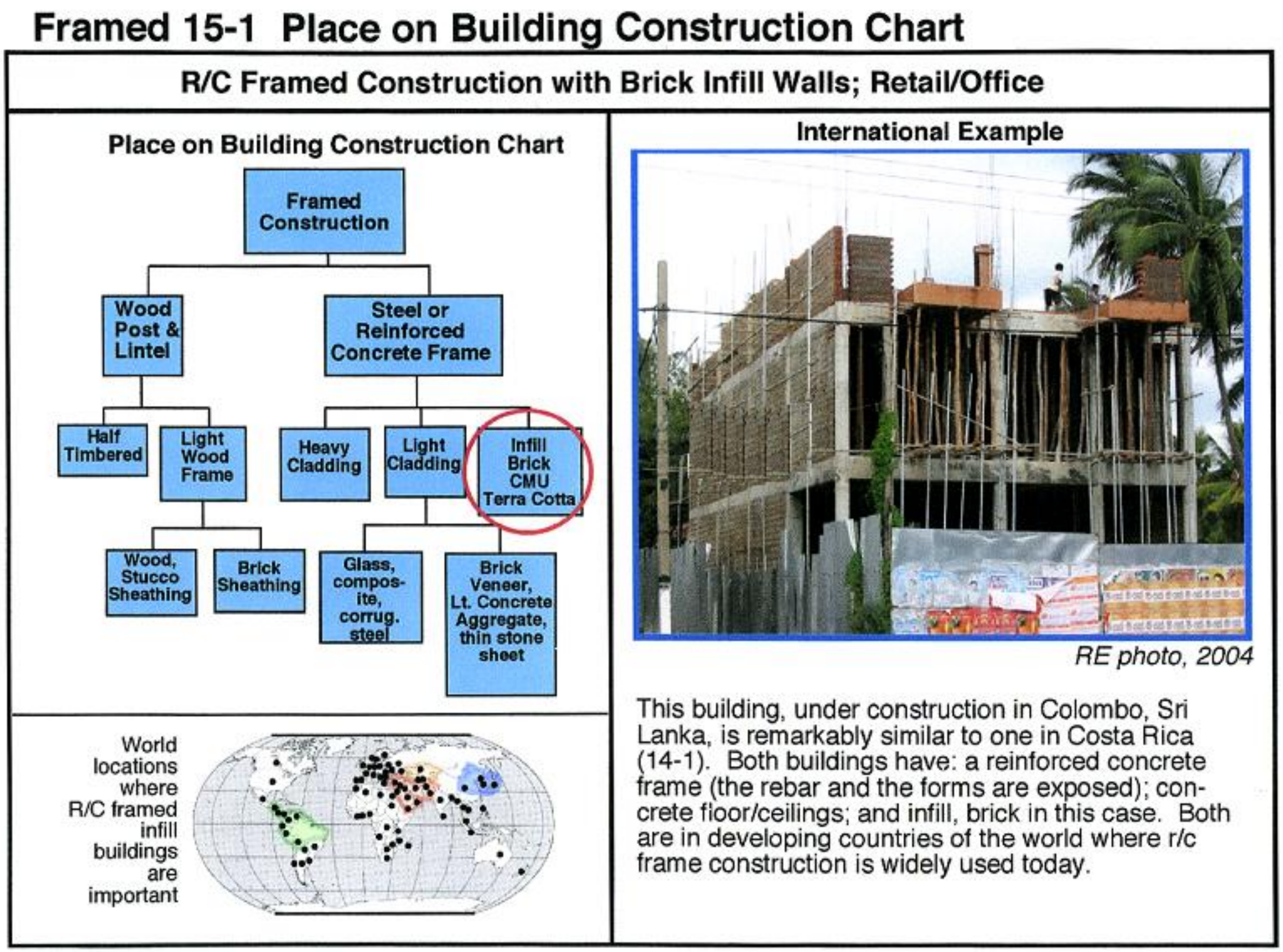


Figure 240. Framed 15-1 place on building construction chart.

Framed 15-2 Elevations

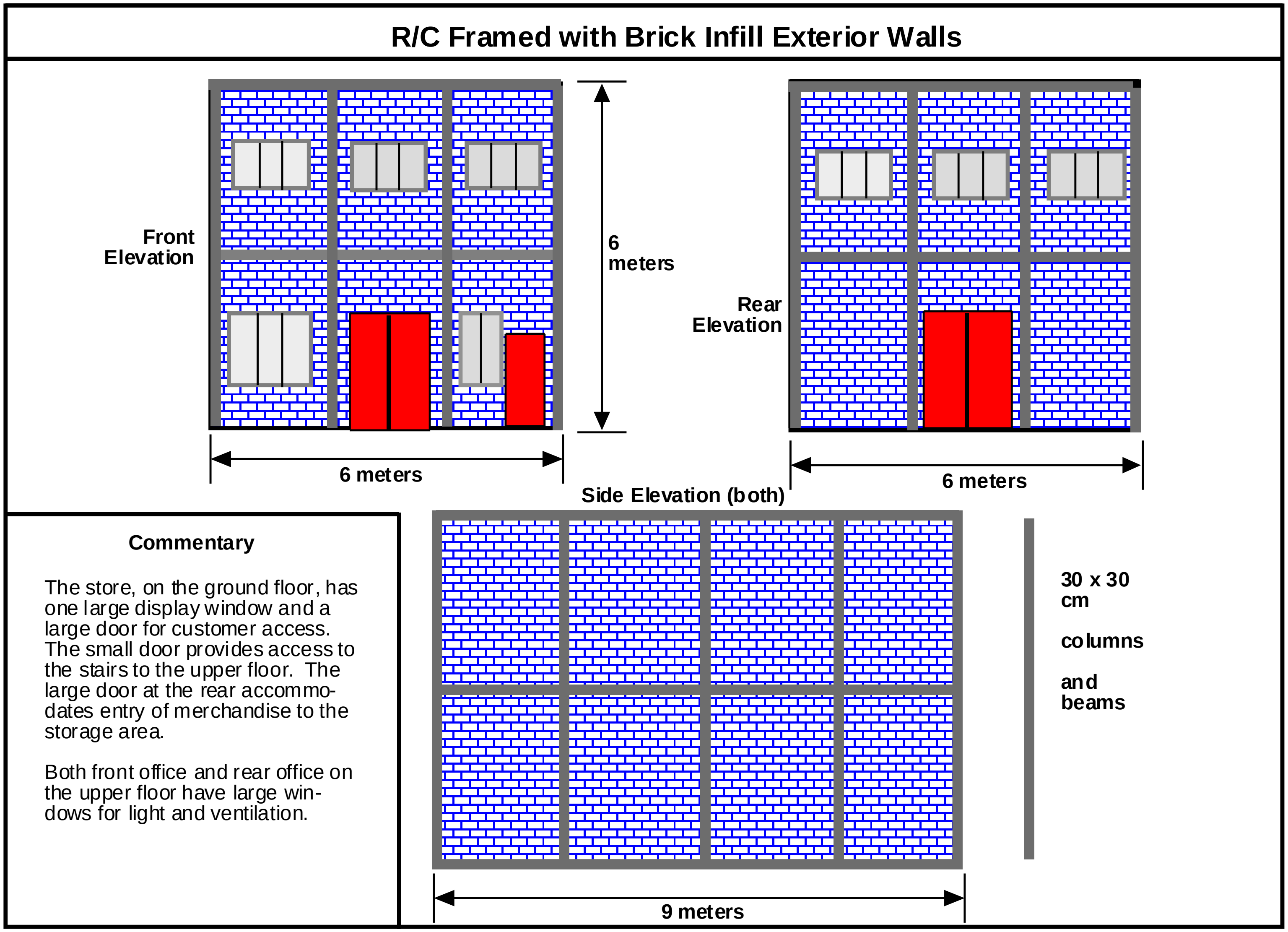
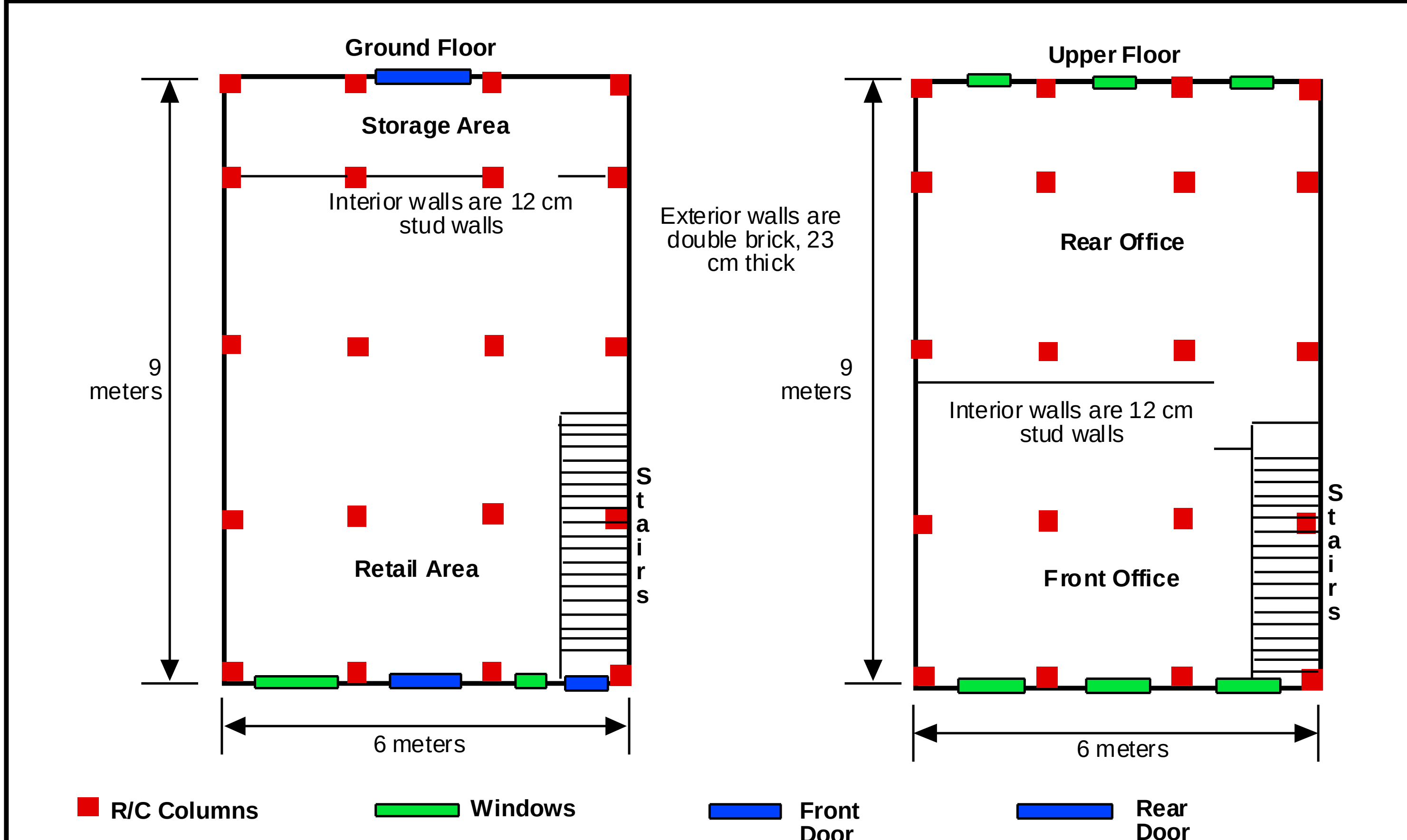


Figure 241. Framed 15-2 elevations.

Framed 15-3-a Floor Plans

R/C Framed with Brick Infill Exterior Walls



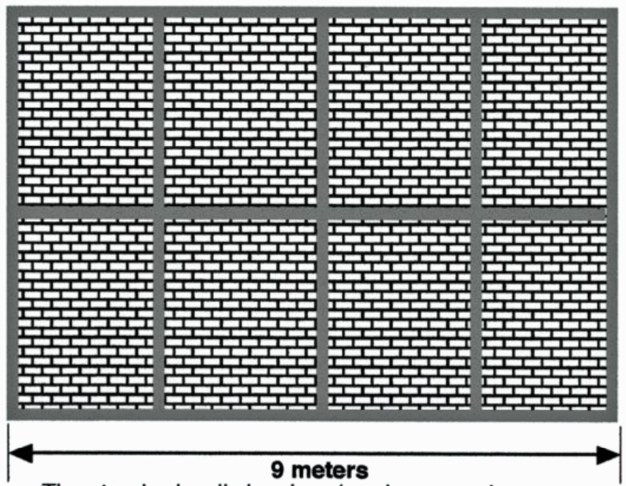
Commentary

The above is a common situation. A retail store occupies the ground floor to make maximal use of access to potential passing customers. The upper floor, less accessible, is occupied by two offices, reachable by a stairway with its ground floor entrance at the front of the building.

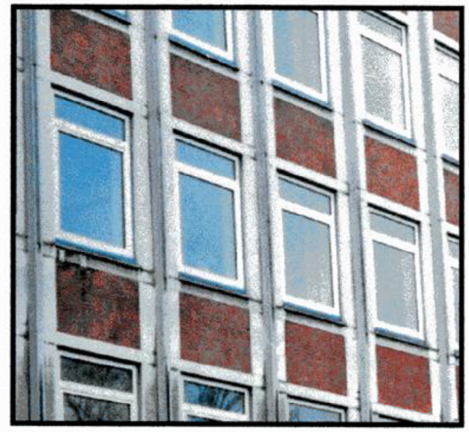
Figure 242. Framed 15-3-a floor plans.

Framed 15-4 Construction

R/C Framed with Brick Infill Exterior Walls



The standard wall showing r/c columns and beams and brick infill walls.



Commentary

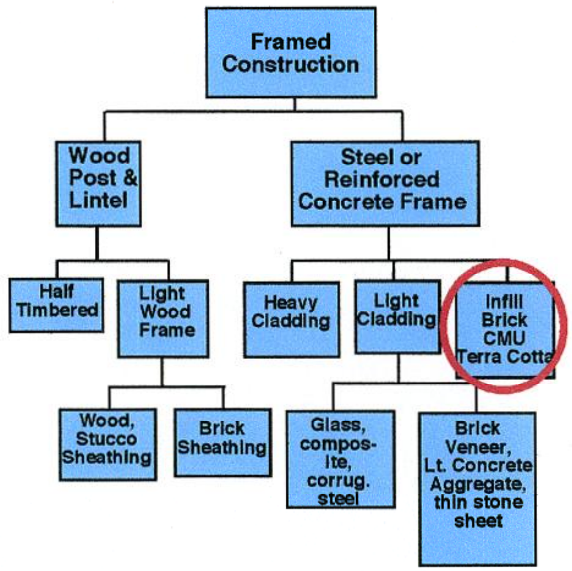
Brick infill can vary greatly in quantity and quality. The upper right example, a street-facing side of a building in Bremen, Germany, uses a refined form of brick infill between R/C mullions. The lower right example, a building in Tel Aviv, Israel, reveals an exceptionally wide (approximately 50 cm) column (with the pattern of the wooden forms still showing). The brick infill is of a size common to the Middle East (23 x 11.5 x 5.7 cm). The wall uses English bond and is apparently three bricks (triple brick) thick. Grouting is irregular indicating that the wall is not structural but serves only to enclose space and provide protection from the elements.

Figure 243. Framed 15-4 construction.

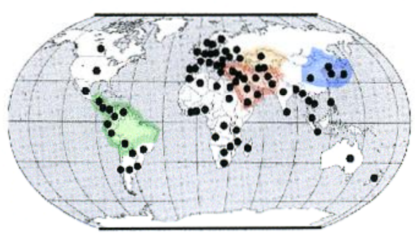
Framed 16-1 Place on Building Construction Chart

R/C Framed Construction Industrial/Storage Building with CMU Infill

Place on Building Construction Chart



World locations where R/C framed infill buildings are important



International Example

RE photo.

This example of CMU infill in an r/c framed industrial/storage building, in Bangkok (2004), demonstrates well the heavy use of concrete in modern construction in a developing country. The form of structure meets modern needs, is relatively inexpensive to construct, and withstands the excessive weathering by the elements found in moist, tropical countries. The ventilation in the upper story is a good indicator of response to climate. The model temple, at the right, manifests the deeply religious aspect of Thailand.

Figure 244. Framed 16-1 place on building construction chart.

Framed 16-2-a Elevation

R/C Framed Construction Industrial/Storage Building (with CMU Infill)

Construction Method and Dimensions

Commentary

This elevation (front of building) displays common elements found in such structures. Loads are borne by the reinforced concrete columns and beams. The columns rest on a mass construction reinforced concrete perimeter foundation that is 1 m tall and 20 cm thick. The infill walls are made with CMU blocks that are also 20 cm thick.

The roof (of corrugated sheet metal in this example) is supported by steel trusses supported by the top beam.

The truck entrance to the large open area within the building is 3.0 x 4 m. The person door, leading to the office, is a standard 1 x 2 m. The single window is also 2 x 1 m.

The window indicates the location of the office.

Front Elevation

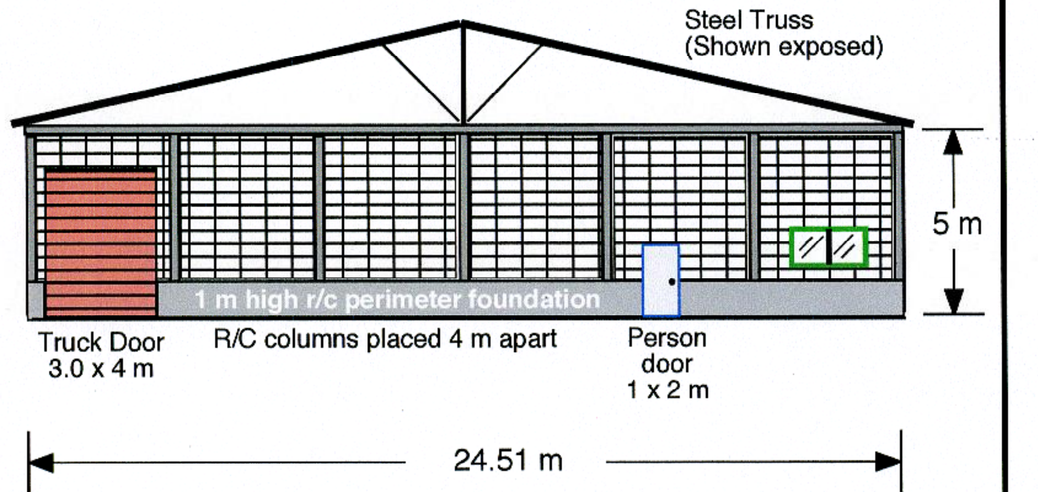


Figure 245. Framed 16-2-a elevation.

Framed 16-2-b Elevation

R/C Framed Construction Industrial/Storage Building (with CMU Infill)

Construction Method and Dimensions

Commentary

This rear elevation has the same physical characteristics as the front elevation but shows the doors in their proper locations.

The roof (of corrugated sheet metal in this example) is supported by steel trusses supported by the top beam.

The truck entrance to the large open area within the building is 3.0 x 4 m. The person door is a standard 1 x 2 m.

Rear Elevation

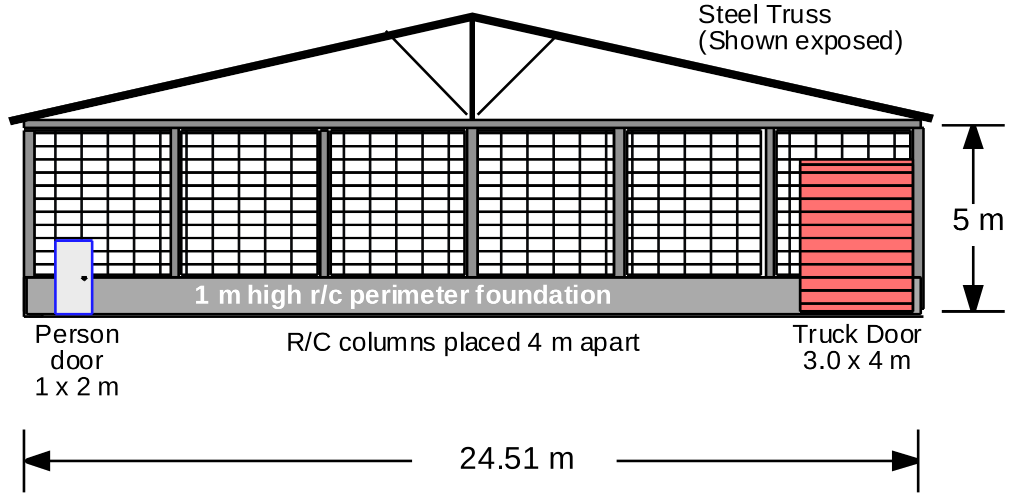


Figure 246. Framed 16-2-b elevation.

Framed 16-3-a Floor Plan

R/C Framed Industrial/Storage Building with CMU Infill

Commentary

Manufacturing/storage buildings constructed in the last 50 years have taken a shape that meets the need for access by truck. Older buildings reflected their particular needs: e.g., high-rise structures were constructed at water power sites; with the coming of railroads, buildings were designed with long sides parallel to railroad lines to allow loading several railroad cars simultaneously.

Modern buildings have large doors for truck access (height of about 4 m, and width of 3 m).

In common with older structures is the need for both large planimetric floor space and height. Lighting is often achieved through use of skylights ("saw-tooth" arrangements of windows were frequently used in the past).

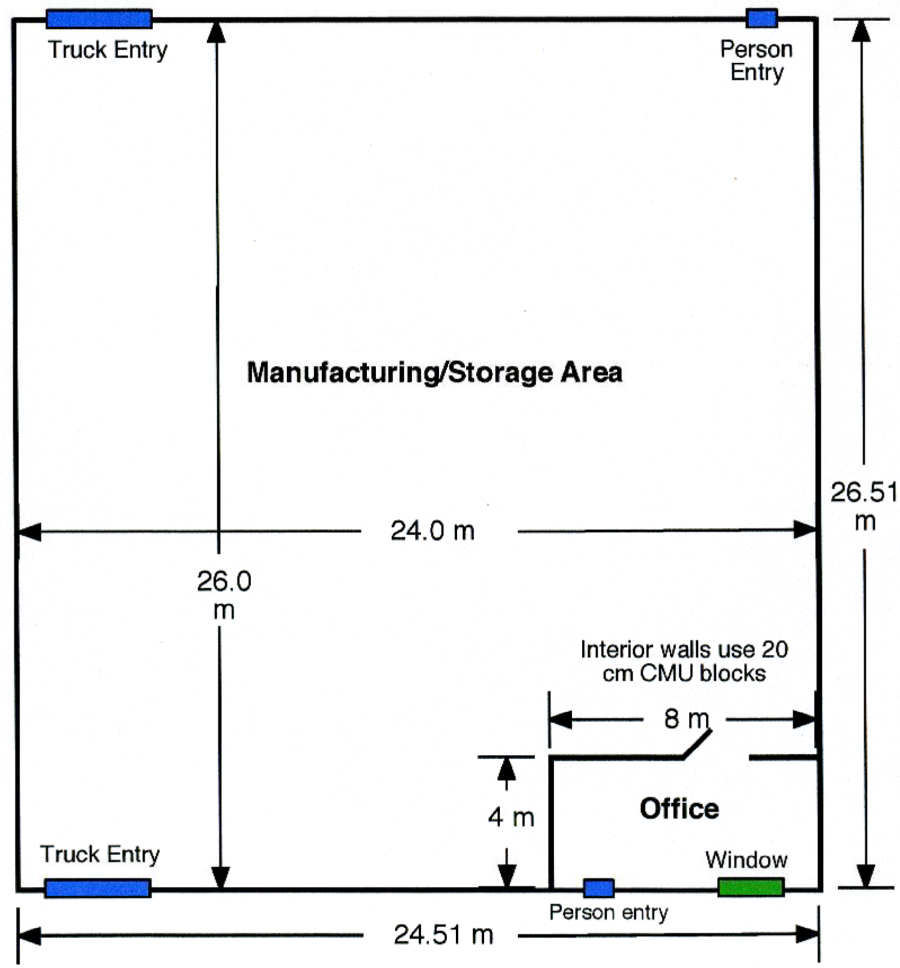


Figure 247. Framed 16-3-a floor plan.

Framed 16-4 Construction

R/C Framed Industrial/Storage Building with CMU Infill

Commentary

Manufacturing/storage buildings constructed in the last 50 years have taken a shape that meets the need for access by truck. Older buildings reflected their particular needs: e.g., high-rise structures were constructed at water power sites; with the coming of railroads, buildings were designed with long sides parallel to railroad lines to allow loading several railroad cars simultaneously.

Modern buildings have large doors for truck access (height of about 4 m, and width of 3 m).

In common with older structures is the need for both large planimetric floor space and height. Lighting is often achieved through use of sky-lights ("saw-tooth" arrangements of windows were frequently used in the past).

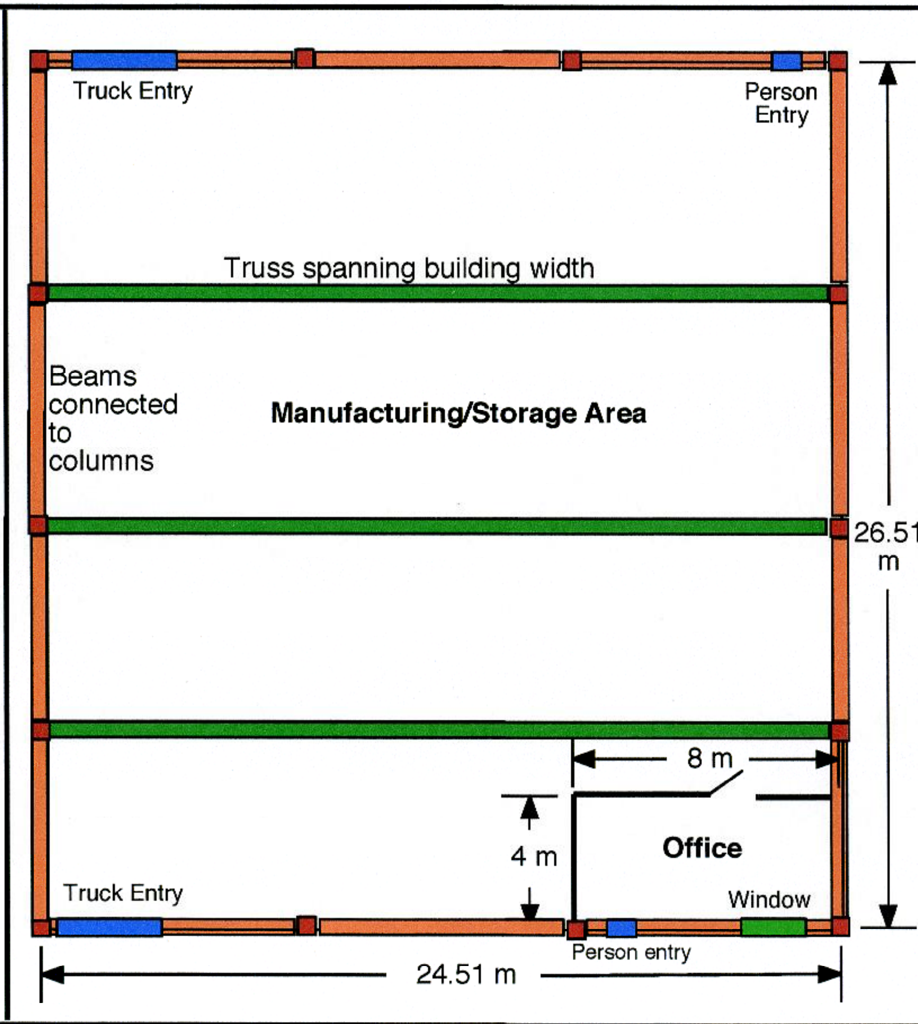
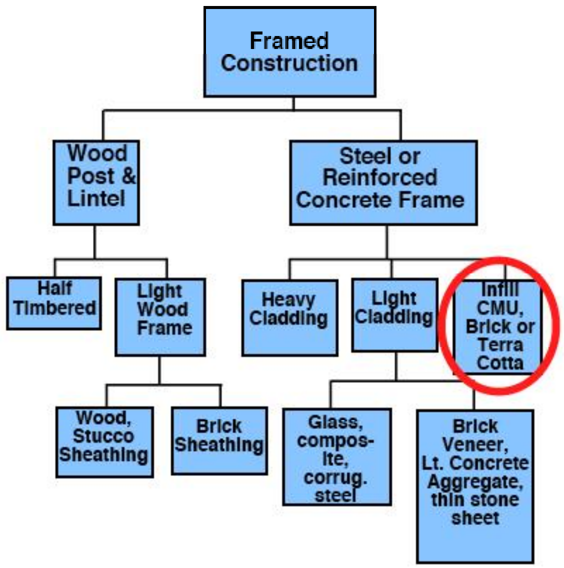


Figure 248. Framed 16-4 construction.

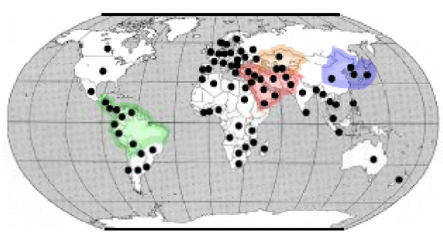
Framed 17-1 Place on Building Construction Chart

R/C Framed Construction Industrial/Storage Building With Terra Cotta Infill

Place on Building Construction Chart



World locations where R/C framed infill buildings are important



International Example

RE photo.

This industrial/storage building, on St. Croix, is an example of how terra cotta, rather than CMU or brick, can be used as infill.

Figure 249. Framed 17-1 place on building construction chart.

Framed 17-2-a Elevation

R/C Framed Construction Industrial/Storage Building (with Terra Cotta Infill)

Construction Method and Dimensions

Commentary

This elevation (front of building) displays common elements found in such structures. Loads are borne by the reinforced concrete columns and beams; beams rest on corbels. The columns rest on a mass construction reinforced concrete perimeter foundation and is 1 m tall and 20 cm thick. Terra cotta infill measures 40 cm by 25 cm x 25 cm) and the wall is thus 25 cm thick.

The roof (of corrugated sheet metal in this example) is supported by steel trusses supported by the top beam.

The truck entrance to the large open area within the building is 3.0 x 4 m. The person door, leading to the office, is a standard 1 x 2 m. The single window, also 2 x 1 m, shows office location.

Front Elevation

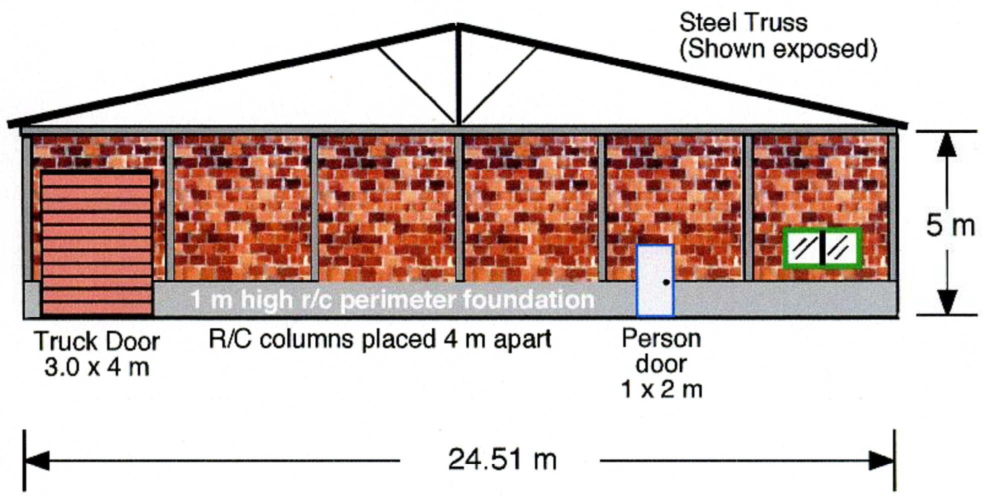


Figure 250. Framed 17-2-a elevation.

Framed 17-2-b Elevation

R/C Framed Construction Industrial/Storage Building (with Terra Cotta Infill)

Construction Method and Dimensions

Commentary

This rear elevation has the same physical characteristics as the front elevation but shows the doors in their proper locations.

The roof (of corrugated sheet metal in this example) is supported by steel trusses supported by the top beam.

The truck entrance to the large open area within the building is 3.0 x 4 m. The person door is a standard 1 x 2 m.

Rear Elevation

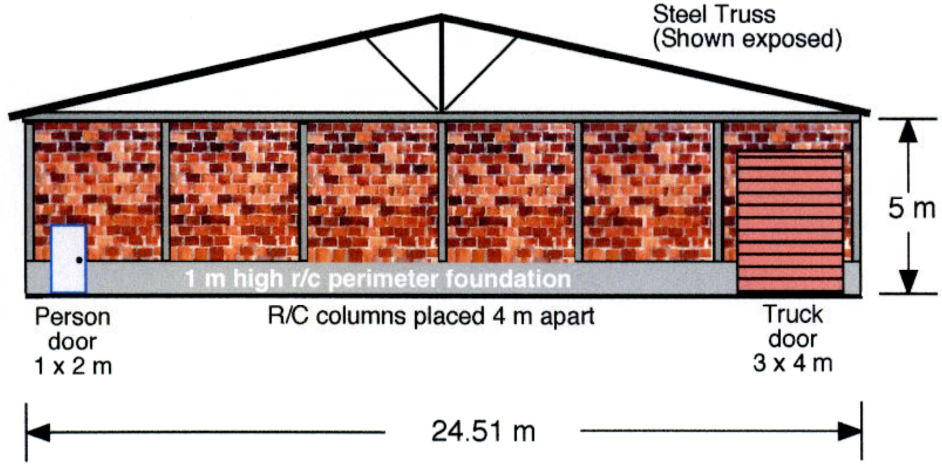


Figure 251. Framed 17-2-b elevation.

Framed 17-3-a Floor Plan

R/C Framed Industrial/Storage Building with Terra Cotta Infill

Commentary

Manufacturing/storage buildings constructed in the last 50 years have taken a shape that meets the need for access by truck. Older buildings reflected their particular needs: e.g., high-rise structures were constructed at water power sites; with the coming of railroads, buildings were designed with long sides parallel to railroad lines to allow loading several railroad cars simultaneously.

Modern buildings have large doors for truck access (height of about 4 m, and width of 3 m).

Common with older structures is the need for both large planimetric floor space and height. Lighting is often achieved through use of skylights (“saw-tooth” arrangements of windows were frequently used in the past).

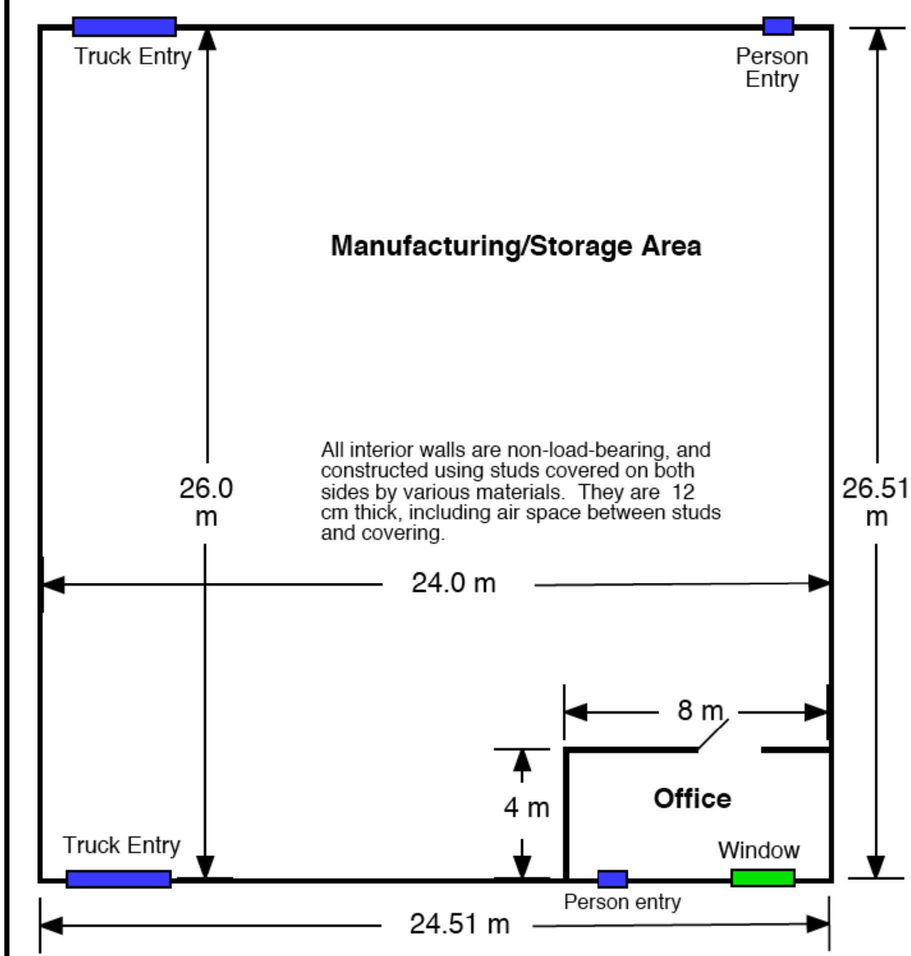


Figure 252. Framed 17-3-a floor plan.

Framed 17-4 Construction

R/C Framed Industrial/Storage Building with Terra Cotta Infill

Commentary

Manufacturing/storage buildings constructed in the last 50 years have taken a shape that meets the need for access by truck. Older buildings reflected their particular needs: e.g., high-rise structures were constructed at water power sites; with the coming of railroads, buildings were designed with long sides parallel to railroad lines to allow loading several railroad cars simultaneously.

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In common with older structures is the need for both large planimetric floor space and height. Lighting is often achieved through use of skylights ("saw-tooth" arrangements of windows were frequently used in the past).

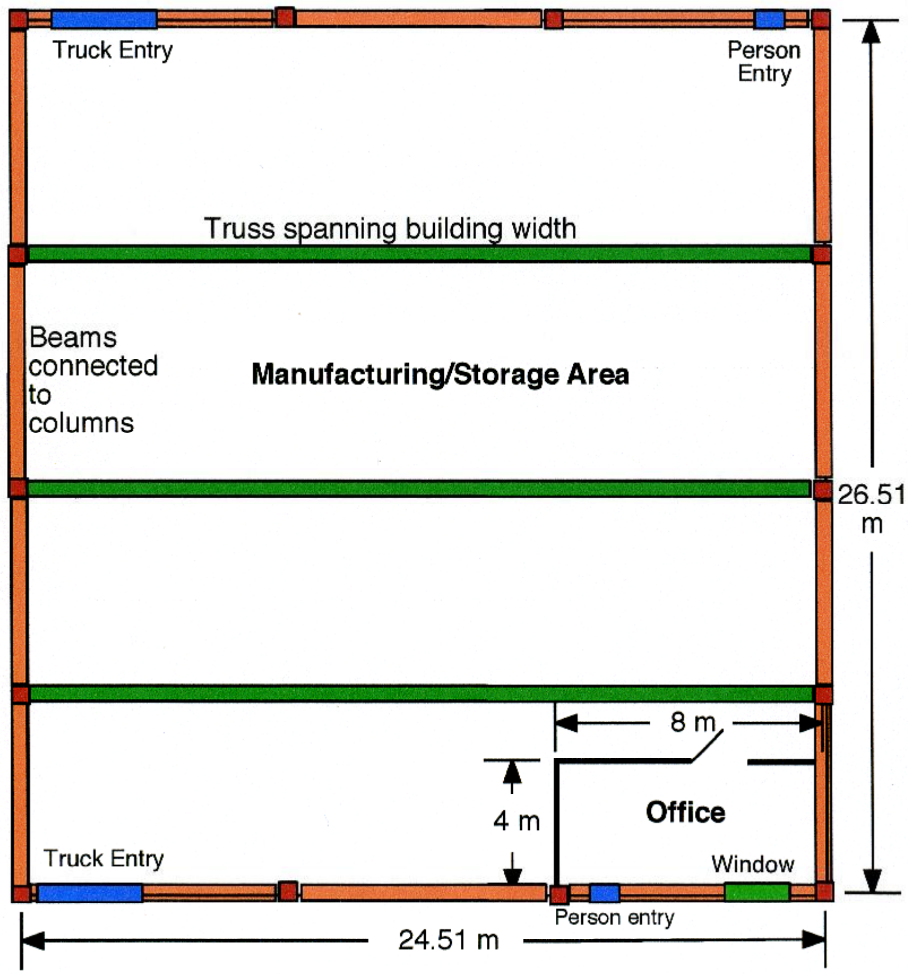

Figure 253. Framed 17-4 construction.

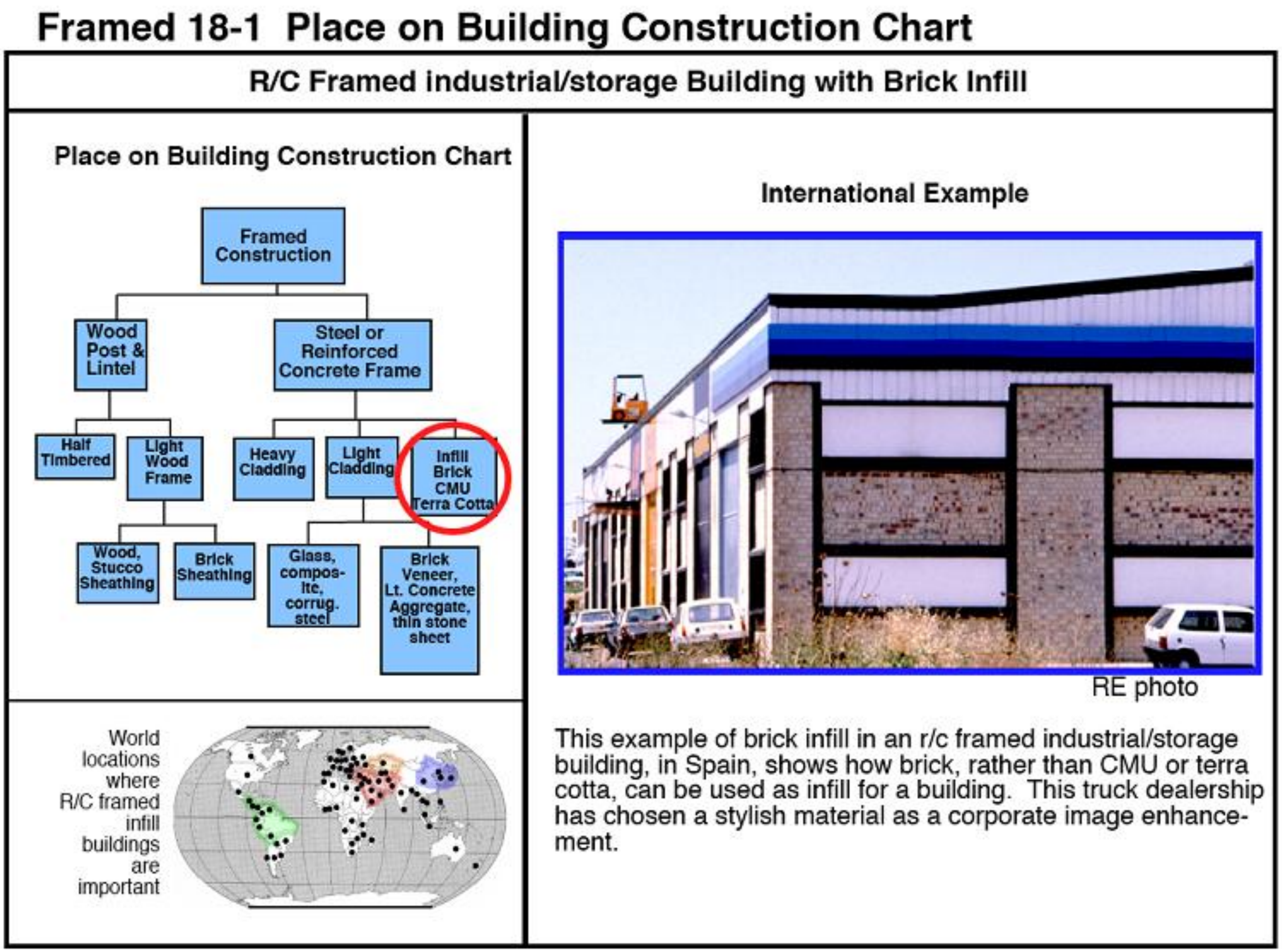

Figure 254. Framed 18-1 place on building construction chart.

Framed 18-2-a Elevation

R/C Framed Construction Industrial/Storage Building (with Brick Infill)

Commentary

This front elevation displays common elements found in such structures. Loads are borne by the reinforced concrete columns and beams; beams rest on corbels. The columns rest on a 1 meter high, 25 cm thick mass construction reinforced concrete perimeter foundation. 23 cm brick infill walls fill space between columns.

The roof (of corrugated sheet metal in this example) is supported by steel trusses supported by the top beam.

The truck entrance to the large open area within the building is 3 x 4 m. The person door, leading to the office, is a standard 1 x 2 m. The single window, 2 x 1 m, shows office location.

Front Elevation

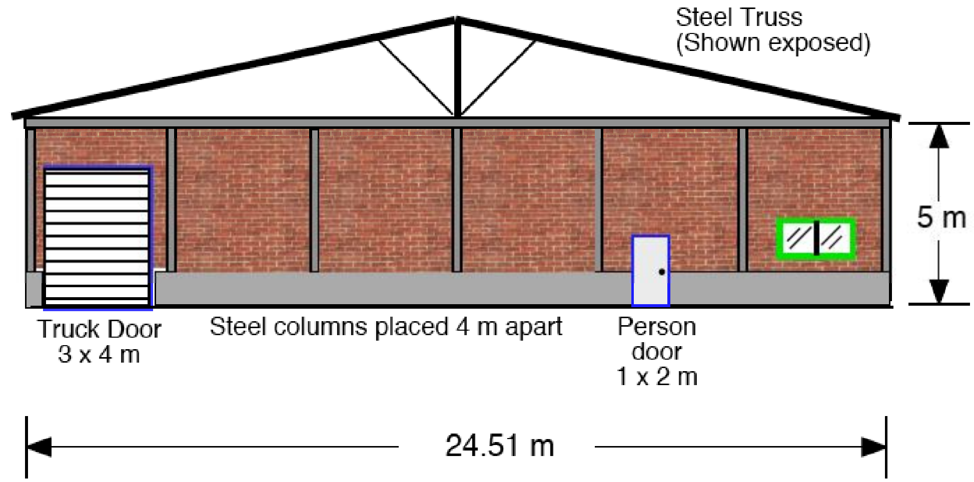

Figure 255. Framed 18-2-a elevation.

Framed 18-2-b Elevation

R/C Framed Construction Industrial/Storage Building (with Brick Infill)

Commentary

This rear elevation has the same physical characteristics as the front elevation but shows the doors in their proper locations.

The roof (of corrugated sheet metal in this example) is supported by steel trusses supported by the top beam.

The truck entrance to the large open area within the building is 3 x 4 m. The person door is a standard 1 x 2 m.

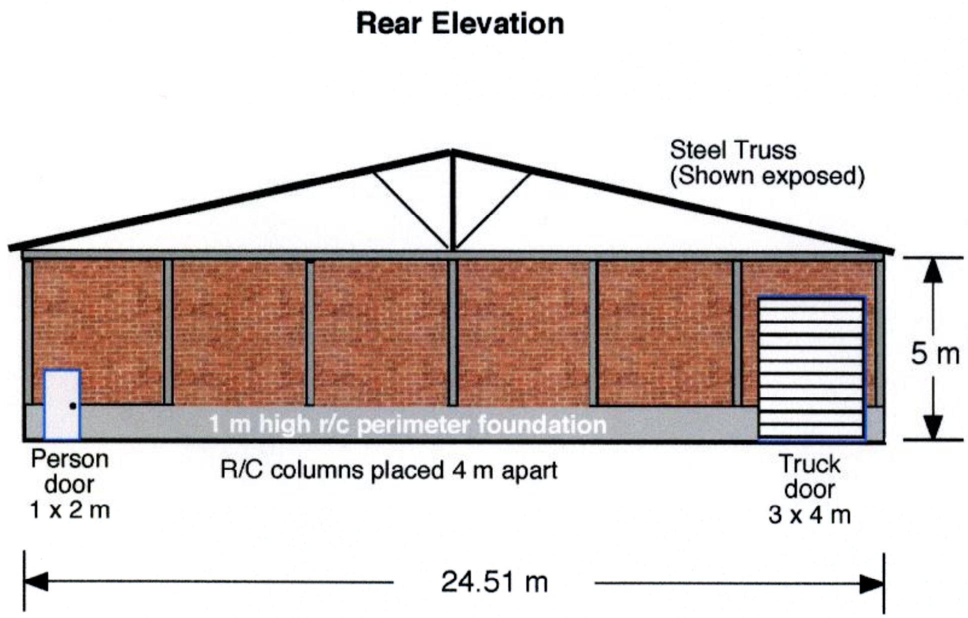

Figure 256. Framed 18-2-b elevation.

Framed 18-3-a   Floor Plan

R/C Framed Industrial/Storage Building with Brick Infill

Commentary

Manufacturing/storage buildings constructed in the last 50 years have taken a shape that meets the need for access by truck. Older buildings reflected their particular needs: e.g., high-rise structures were constructed at water power sites; with the coming of railroads, buildings were designed with long sides parallel to railroad lines to allow loading several railroad cars simultaneously.

Modern buildings have large doors for truck access (height of about 4 m, and width of 3 m).

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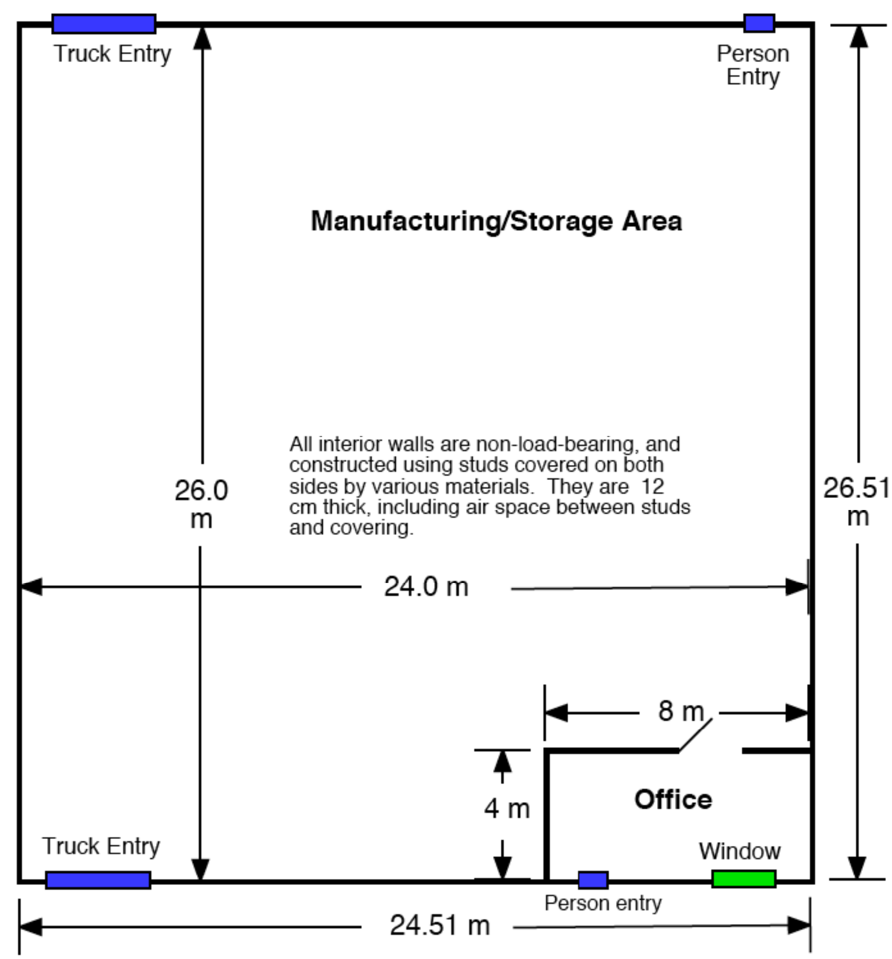

Figure 257. Framed 18-3-a floor plan.

Framed 18-4 Construction

R/C Framed Industrial/Storage Building with Brick Infill

Commentary

Manufacturing/storage buildings constructed in the last 50 years have taken a shape that meets the need for access by truck. Older buildings reflected their particular needs: e.g., high-rise structures were constructed at water power sites; with the coming of railroads, buildings were designed with long sides parallel to railroad lines to allow loading several railroad cars simultaneously.

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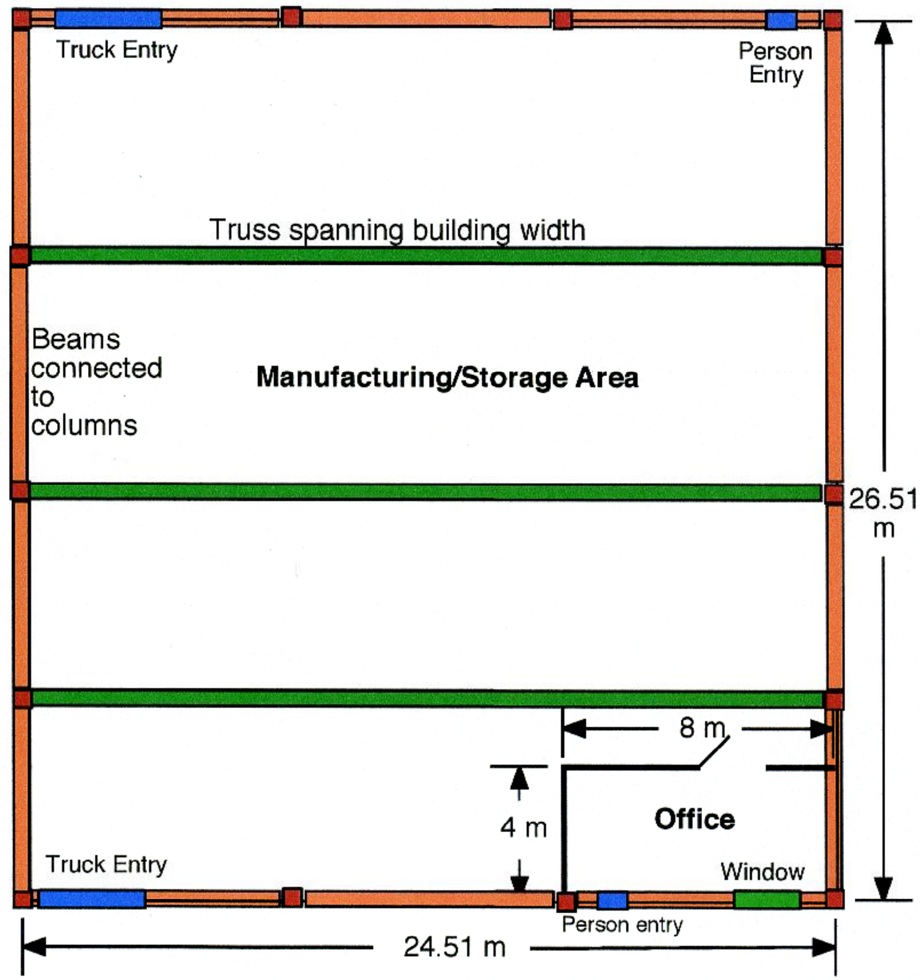
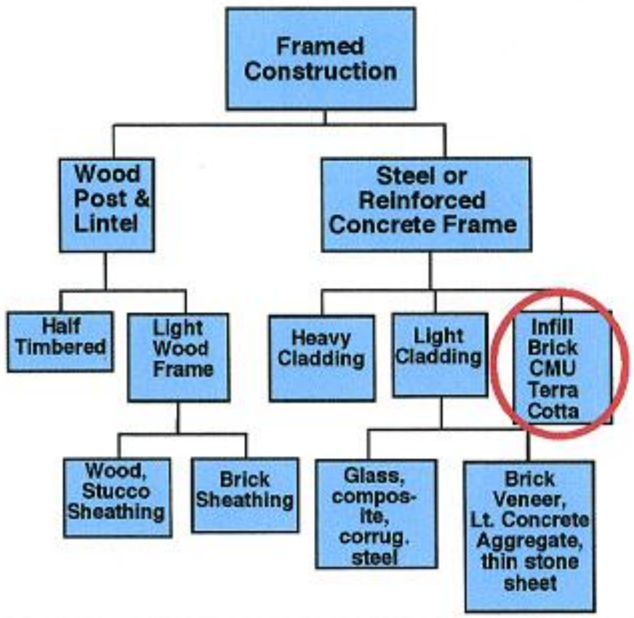


Figure 258. Framed 18-4 construction.

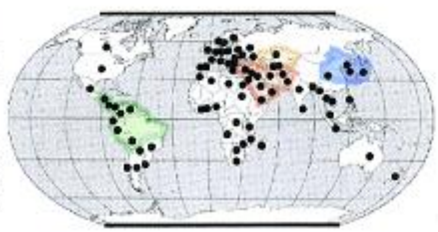
Framed 19-1 Place on Building Construction Chart

R/C Framed Construction School with Brick Veneer over Infill Walls

Place on Building Construction Chart



World locations where R/C framed infill buildings are important



International Example

RE photo.

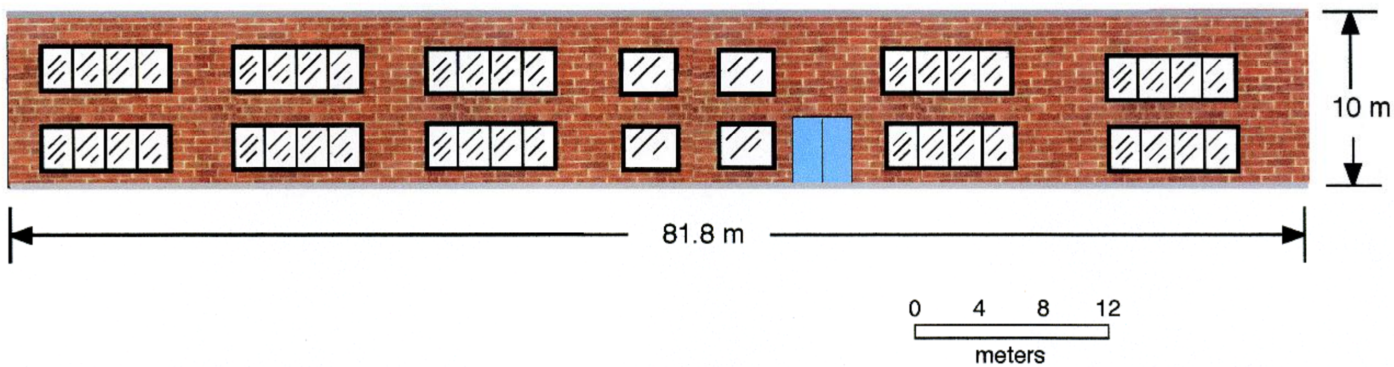
Framed buildings are especially suited to such institutional uses as schools as the long spans of the beams allow the enclosure of large spaces, e.g., classrooms. Infill material between frame members is covered with a brick veneer. This example is in Uppsala, Sweden (1994).

Figure 259. Framed 19-1 place on building construction chart.

Framed 19-2 Elevation

R/C Framed Construction School with Brick Infill Walls

Front Elevation



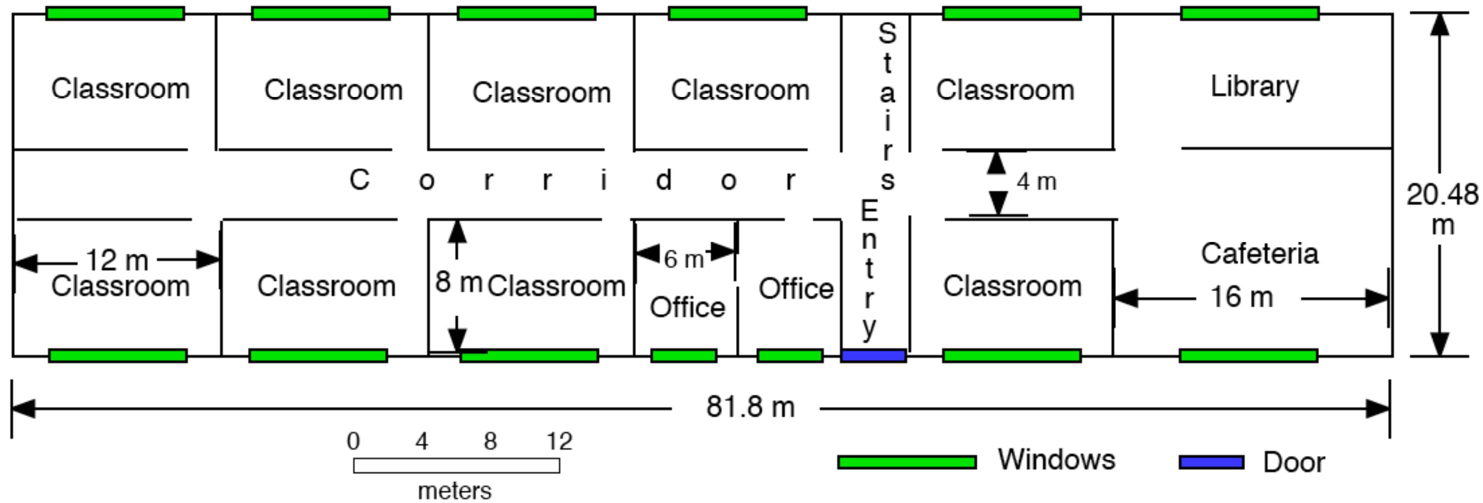
Commentary	This front elevation manifests the building's function as a school by the uniform nature of its repetitive large windows, one for each classroom; the smaller windows serving support functions. The facing brick hides the columns and beams of the structure.

Figure 260. Framed 19-2 elevation.

Framed 19-3-a Floor Plan

R/C Framed Construction School with Brick Infill Walls

Floor Plan, Ground Floor



Commentary	Each function (land use) has its particular set of requirements for the buildings they occupy expressed in terms of room size and shape, venting, room volume, and special facilities (e.g., plumbing for chemistry labs). Further, these requirements are universal. In this example, a school, the primary needs are for classrooms capable of seating common class sizes, a shape that allows a room front area for the teacher and wall space for blackboards. In addition, provision is made for school administration, a library, and a food service area. A long rectangular shape serves these needs readily and allows for large window areas for natural light.

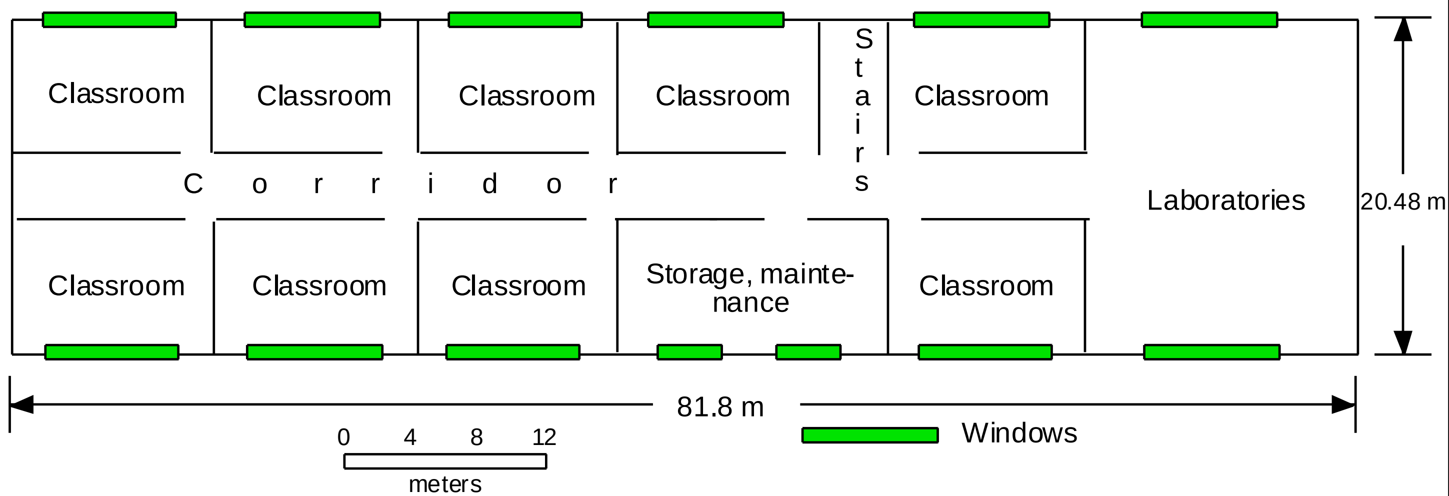
Figure 261. Framed 19-3-a floor plan.

Framed 19-3-b Floor Plan

R/C Framed Construction School with Brick Infill Walls

Floor Plan: School

Floor Plan, Upper Floor



Commentary

The upper floor of this school is similar to the ground floor but substitutes storage and laboratories for offices and other uses in the floor below.

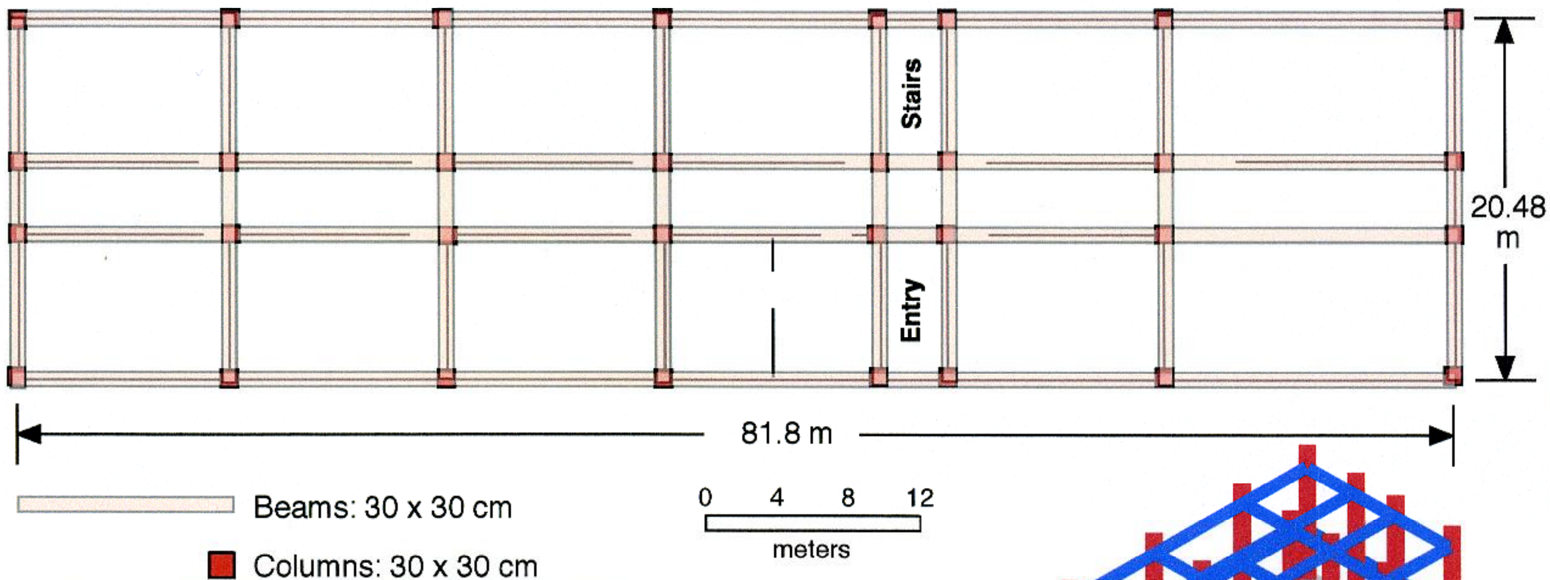
Figure 262. Framed 19-3-b floor plan.

Framed 19-4 Construction

R/C Framed Construction School with Brick Infill Walls

Construction Method and Dimensions

Frame



Commentary
Columns are placed 12 m apart on the long axis; 8 and 4 on the short axis, except where closer to provide extra support for the entry and stairs. Connections use tied rebar, enclosed in concrete.

Columns and beams of a two story r/c framed building.

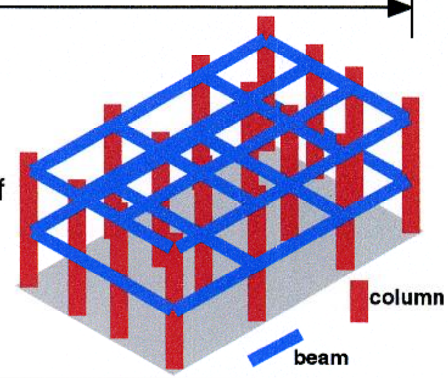
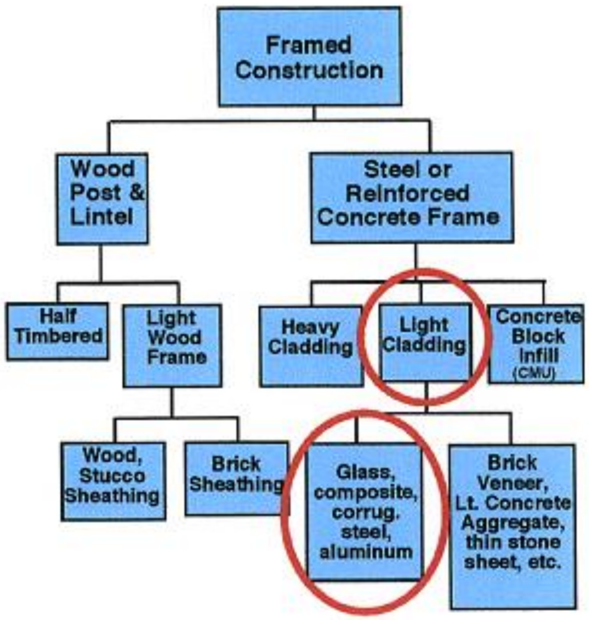


Figure 263. Framed 19-4 construction.

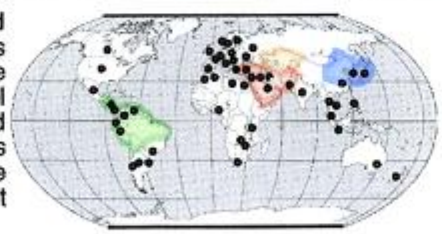
Framed 20-1 Place on Building Construction Chart

Steel-framed, Light cladding Industrial/Storage Building

Place on Building Construction Chart



World locations where R/C-Steel Light clad buildings are important



International Examples

German building with composite corrugated outer cover. *RE Photo.*

Simple steel framed, corrugated aluminum partially covered building on the island of Yap. *RE Photo.*

Figure 264. Framed 20-1 place on building construction chart.

Framed 20-2 Elevation

Steel-framed, Light cladding Industrial/Storage Building

Steel Frame with Corrugated Steel Cladding

Commentary

Steel framing with light, corrugated steel (or some composite) cladding is commonly used in industrial/storage buildings throughout the world. Steel I shaped members are used for both columns and beams (at the wall top), joined with bolts. Columns are placed three meters apart, in this example.

Columns are anchored to the reinforced concrete perimeter foundation.

A long spandrel window provides venting on the side elevations. End elevations have the same doors and windows as the framed with infill examples.

Side Elevation

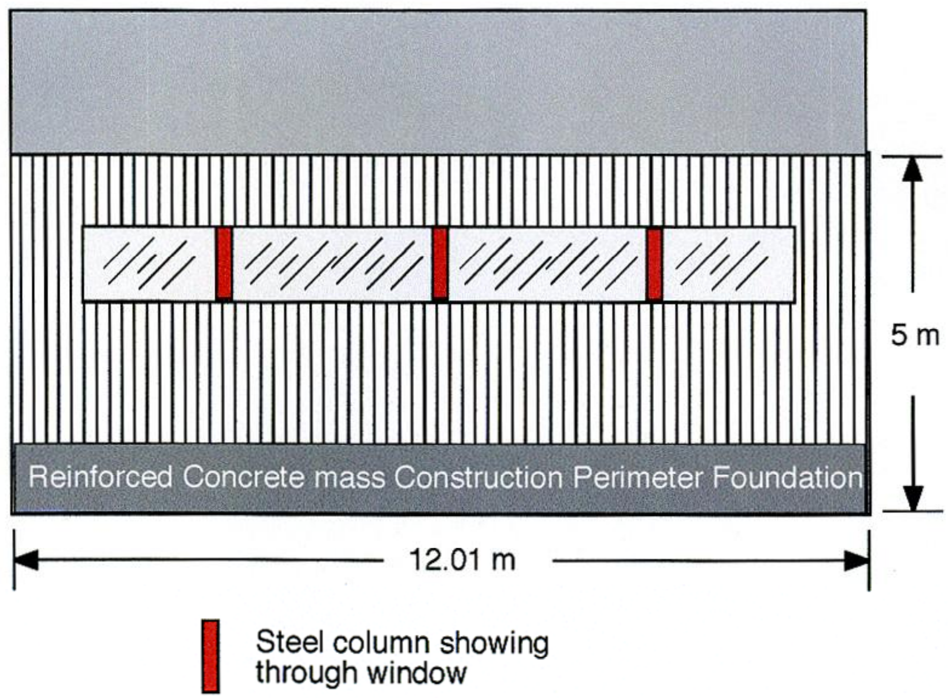


Figure 265. Framed 20-2 elevation.

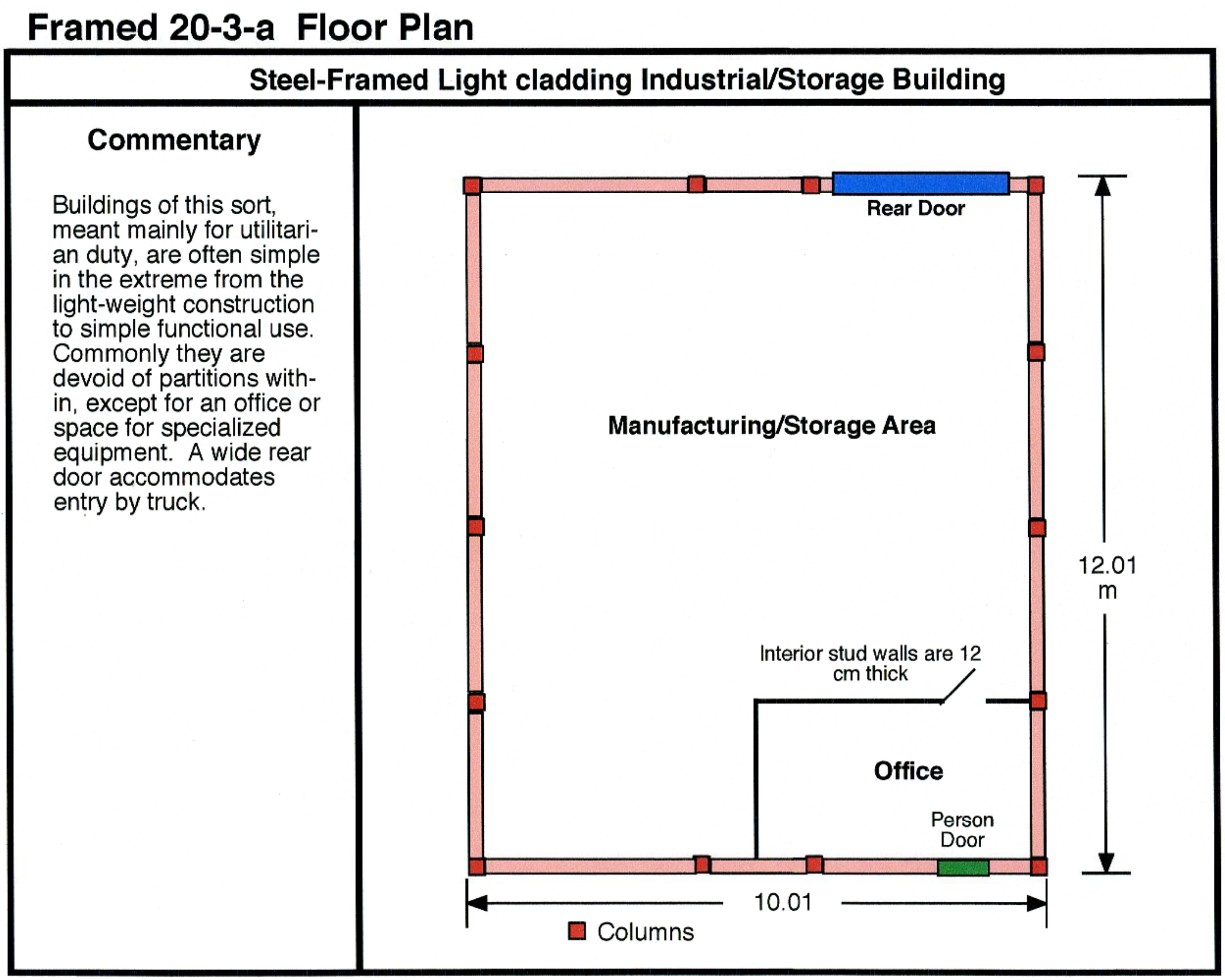


Figure 266. Framed 20-3-a floor plan.

Framed 20-4 Construction

Steel-framed, Light cladding Industrial/Storage Building

Steel framing

Commentary

A simple steel frame is used in this type of manufacturing/storage building. Columns are 3 meters apart on the long axis of the building, and spaced appropriately on the end walls. These are connected, at the roof level, by steel beams. The connections between columns and beams are bolted.

Columns and beams have a capital I shape, and are 30 cm wide.

The floor space is enclosed, without supporting columns within, by roof trusses resting on the side columns.

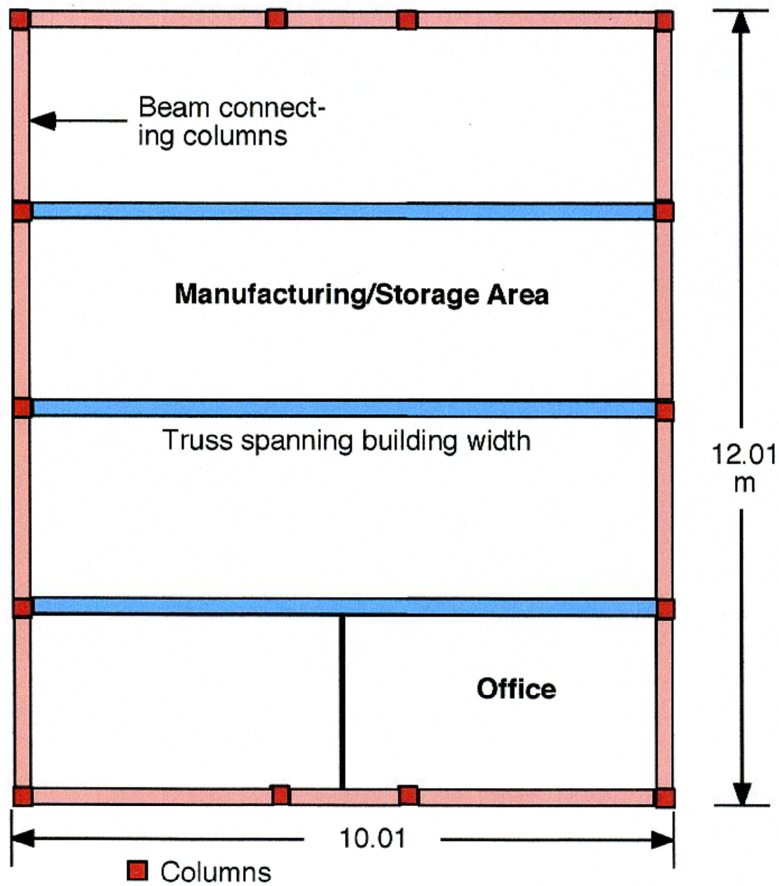
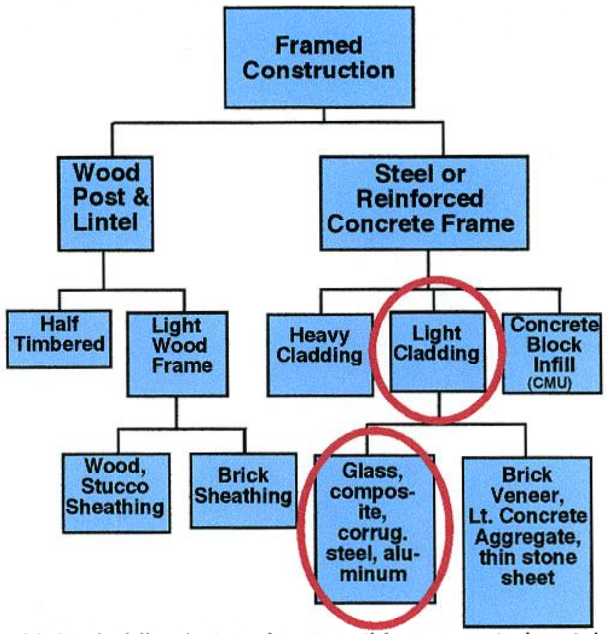


Figure 267. Framed 20-4 construction.

Framed 21-1 Place on Building Construction Chart

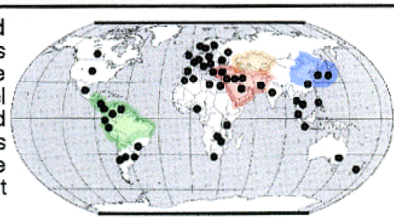
Corrugated Steel Panels on a Steel Framed Industrial Building (Multiple unit)

Place on Building Construction Chart

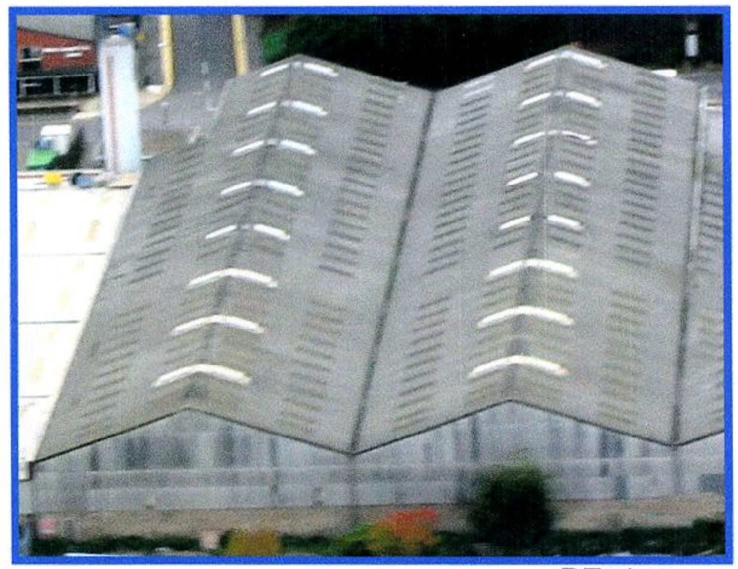


Light cladding here refers to a thin corrugated metal skin placed on a steel frame.

World locations where R/C-Steel Light clad buildings are important



International Example



RE photo.

Steel framed industrial/storage building, in England, placed on a reinforced concrete perimeter foundation. Outer wall uses corrugated steel. Roof panels are corrugated composite material. Skylights are common in this type of structure.

Figure 268. Framed 21-1 place on building construction chart.

Framed 21-2 Elevation

Corrugated Steel Panels on a Steel-Framed Industrial/Storage Building (multiple unit)

Commentary

The end view elevation of this twin building shows the very limited entry: the truck door and the person door. Ventilation is limited, but little needed given the industrial or storage function of the building. Natural interior lighting is provided by the skylights.

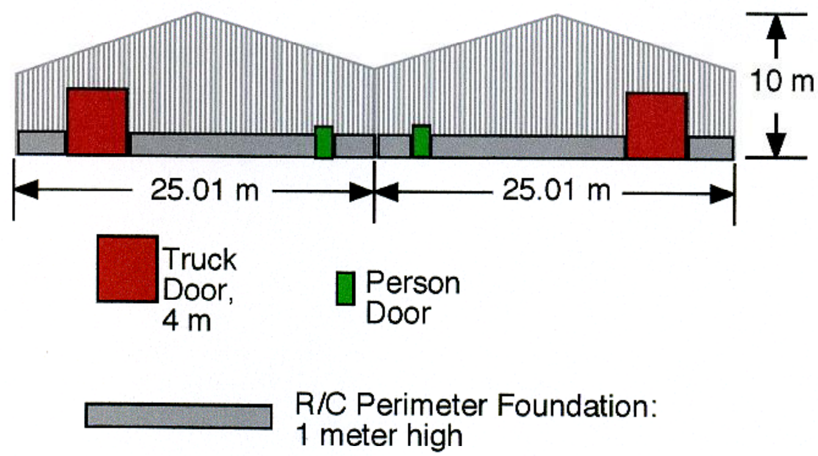


Figure 269. Framed 21-2 elevation.

Framed 21-3-a Floor Plan

Corrugated Steel Panels on a Steel-Framed Industrial/Storage Building (multiple unit)

Commentary

Buildings of this type, very common throughout the world, are designed to enclose large areas of space with few, or no, internal columns to impede the manufacturing or storage function. In this example, twin buildings have been constructed side by side, a common mode. The method has the advantage of obviating the need for extraordinarily long spans or a very high roof, if the building were but a single structure.

Floor Plan, Pair of Industrial/Storage Buildings

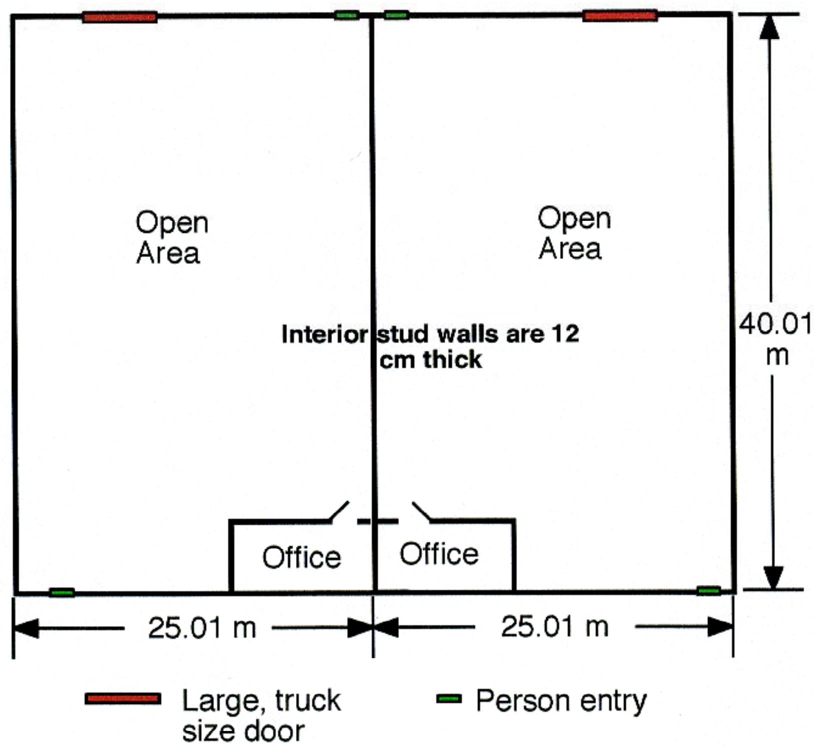
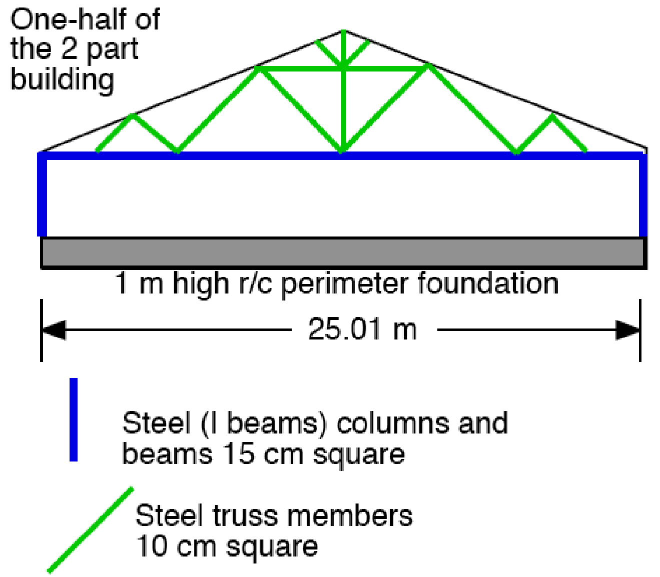


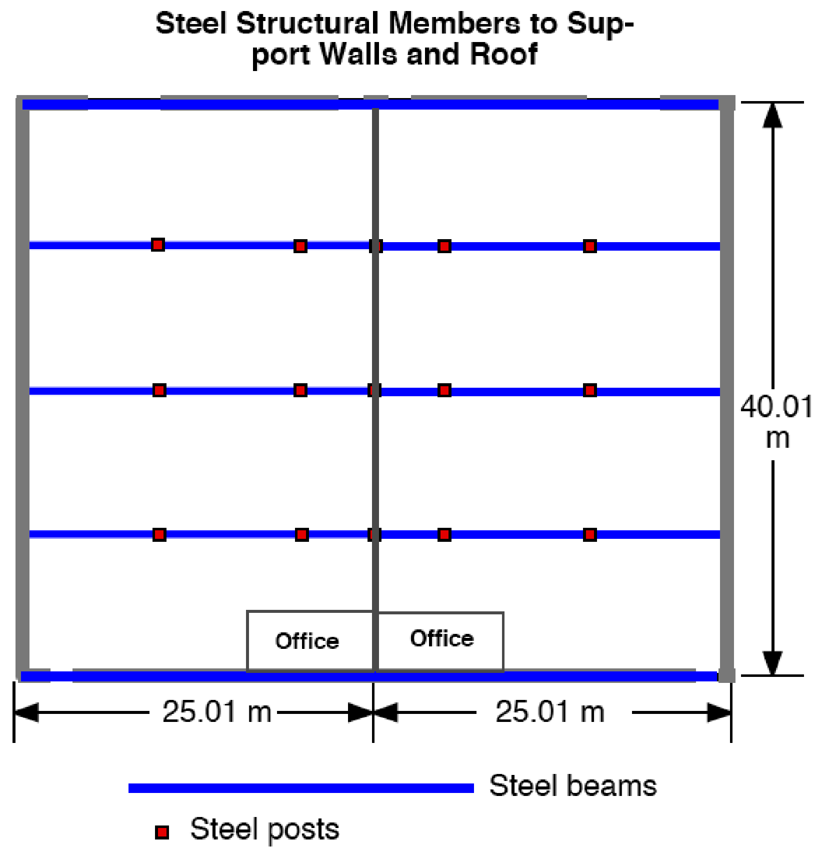
Figure 270. Framed 21-3-a floor plan.

Framed 21-4 Construction

Corrugated Steel Panels on a Steel-Framed Industrial/Storage Building (multiple unit)

Structural Details





Commentary

The light weight of walls and roof requires only minimal size supporting steel beam columns and beams. Use of a truss, with its cross bracing, also requires only light steel structural members. Columns and beams are spaced 10 meters apart, except where the two halves of the building meet. Support columns rest on and are attached to the r/c perimeter foundation.

Figure 271. Framed 21-4 construction.

13. Urban Terrain Zones

The UTZ inventory system plays an integral supporting role to the UTBTs depicted in this report. While the building type catalog provides details on the characteristics of each structure type, the UTZs give them a locational home within a city. Indeed, the UTZ system—applicable worldwide—was designed for the express purpose of providing the urban operations planner with information on the nature of buildings to be anticipated in various parts (zones) of the urban environment.

To delineate a UTZ, the presence of various building types and settings is first observed, either from synoptic aerial or satellite views, and confirmed with ground truth if possible. Areas of homogeneous building types then become the UTZs. Then, lines are drawn to bound these homogeneous areas of like buildings; the appropriate UTZ class number is then assigned. For each UTZ plate, the building characteristics are as follows:

1. Building Function and Density (as in the title of each UTZ). The function outlines common land-use classes, i.e., houses, apartments, commercial, industrial, and institutions. The density outlines buildings that are attached (or abutted); detached but closely spaced; or detached and widely spaced.

2. Building Separation. Statement and measurement of the amount of space separating buildings, either attached, closely spaced (less than 13 m), or widely spaced (more than 13 m).

3. Building Setting. Where the UTZ is located within the city, e.g., city core, new residential development at the edge of the city, or along railroad lines.
4. Building Construction Type. The general type of construction is listed, e.g., brick or R/C framed with infill walls.
5. Range of Building Heights. The height is given in stories, ranging from houses 2 to 3 stories, to city core areas with buildings from 5 to 50+ stories.
6. Age. The period when most of the buildings in a UTZ were constructed, e.g., post–World War II for a modern suburban development.

The UTZ system is essentially a method to inventory the morphology of an entire city (covering the full area of the corporate city and its adjacent contiguously built-up area that frequently includes other corporate units and built-up unincorporated areas). Taking such an inventory produces a map on which boundaries demarcating the zones have been drawn (see figures 274 and 275 for examples). For a variety of users—ranging from urban operations to weapons and munitions testers, to combat development, and to the modeling and simulation community—UTZ maps give critical information on the quantity and spatial distribution of the various building construction types. Analysis of the map product quickly reveals, for example, the relative number of framed high-rise buildings vs. low-rise brick houses.

Urban operations can take advantage of the naturally occurring spatial clustering of similar building types in homogeneous zones, or sectors, within a city. This is the product of a universal response to economic laws and principles, such as the A1 UTZ with its attached buildings occupying much of their land parcels to make maximal use of expensive land, made so by being located at significant junction points, such as road intersections or river confluences. In another example, industrial land uses and their associated building types are found along rail lines or at a break-of-bulk point where rails meet navigable water. Urban zoning, coming along later, simply codifies these natural occurring clusters of like land uses.

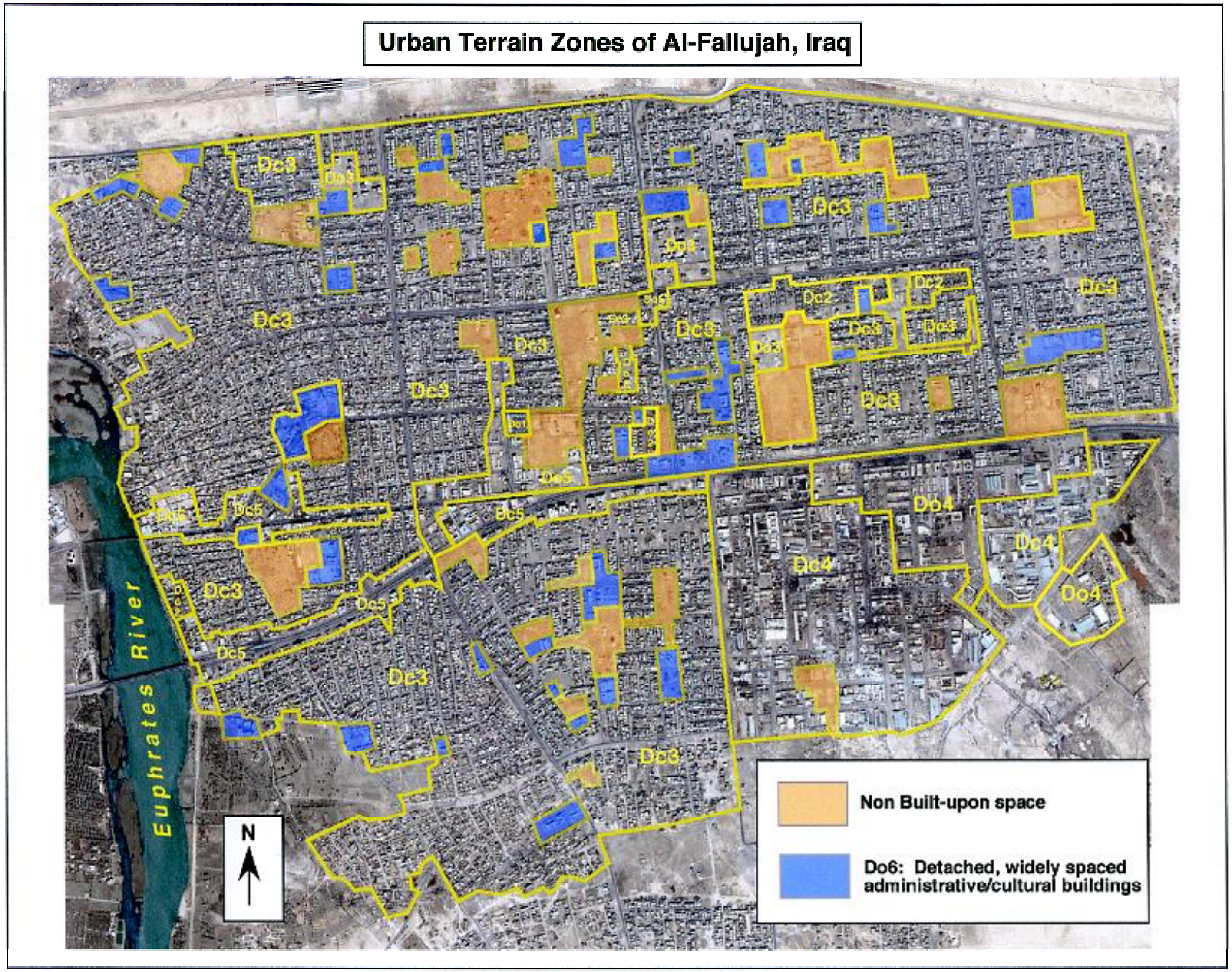


Figure 272. UTZ of Al Fallujah, Iraq.

Contemporary Urban Terrain Zones (UTZs) in a part of the city of Al Fallujah, Iraq

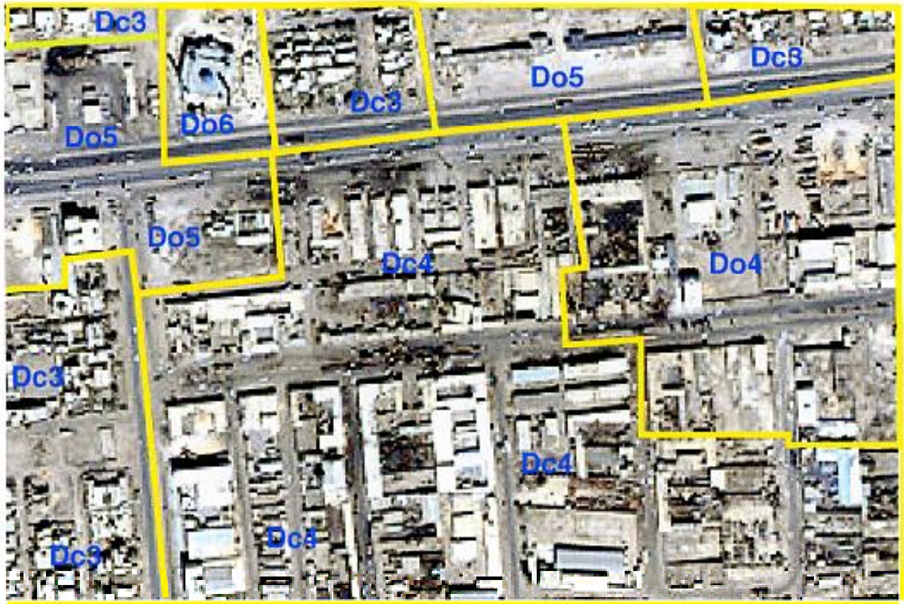


Image from Digital Globe (Quick Bird satellite), 60 cm resolution

0 25 meters
approximate scale

Several Urban Terrain Zones appear in this segment of Al Fallujah. Boundaries are located mainly along the center line of streets. Commercial stores are located along the major boulevard (the Do5 class). The Do6 polygon contains a mosque. Detached industrial/storage buildings are either closely spaced (Dc4) or widely spaced (Do4).

Urban Terrain Zones in this window

Dc: Detached, closely spaced buildings < 13 meters apart

Dc3: Detached, closely spaced houses

Dc4: Detached, closely spaced industrial/storage buildings

Do: Detached, widely spaced buildings > 13 meters apart

Do4: Detached, widely spaced industrial/storage buildings

Do5: Detached, widely spaced commercial buildings

Do6: Detached, widely spaced institutional buildings

Figure 273. Contemporary UTZs in a partial of the city of Al Fallujah, Iraq.

In short, the spatial distribution of the various building types is predictable. Attached buildings occupy expensive land in the city's core and along commercial arterials extending outward. Closely spaced buildings are found near the core on quite expensive land. Widely spaced buildings are found on the least expensive land at the city's periphery or anywhere within the city as they are the product of comprehensive planning, as in an urban redeveloped area or on public space, e.g., a city or national government complex, as in Washington D.C.

The UTZ classification scheme, being a full inventory of a city's homogeneous urban areas, should not be confused with the sort of spatial models seen in such publications as FM 90-10-1 where hypothetical, broad, general zones of a city are portrayed. Examples are city core, commercial ribbon, and outlying high-rise area.

Of special value to using the 44 types of buildings in this document, each UTZ title includes the predominant building type. The complete list, organized into the three basic density groups, is found in table 2.

Urban Terrain Zone (UTZ) A1: Attached Commercial Buildings

Urban Terrain Zone A1

Building Function and Density:
Attached commercial buildings, mainly in city centrum

Building Separation:
Attached along streets

Building Setting:
The evolved part of the city where buildings were built one by one, and not part of a planned whole

Building Construction Type:
Brick buildings, framed heavy clad buildings, and some replacement framed light clad buildings

Range of Building Heights:
5 - 50 Stories

Age:
From several hundred year old brick buildings, to framed heavy clads 1890-1930, to recent light clad buildings

A1 Example: San Jose, Costa Rica

RE Photo

Figure 274. UTZ A1: attached commercial buildings.

Urban Terrain Zone (UTZ) A2: Attached Apartments and Hotels

Urban Terrain Zone A2

Building Function and Density:
Attached apartment and hotel buildings in core periphery

Building Separation:
Attached along streets

Building Setting:
The evolved part of the city where buildings were built one by one, and not part of a planned whole

Building Construction Type:
Brick buildings, framed heavy clad buildings, and some replacement framed light clad buildings

Range of Building Heights:
5 - 10 Stories

Age:
From several hundred year old brick buildings, to framed heavy clads 1890-1930

A2 Example: Budapest, Hungary

RE Photo

Figure 275. UTZ A2: attached apartments and hotels.

Urban Terrain Zone (UTZ) A3: Attached Houses

Urban Terrain Zone A3

Building Function and Density:
Attached houses

Building Separation:
Attached along streets

Building Setting:
The evolved part of the city where buildings were built one by one, and not part of a planned whole

Building Construction Type:
Mainly brick buildings with some framed replacements

Range of Building Heights:
2-3 Stories

Age:
19th and early 20th century

A3 Example: Bremen, Germany

Figure 276. UTZ A3: attached houses.

Urban Terrain Zone (UTZ) A4: Attached Industrial/Storage Buildings

Urban Terrain Zone A4

Building Function and Density:
Attached Industrial/storage

Building Separation:
Attached

Building Setting:
Usually found near the original core of cities

Building Construction Type:
Mainly brick buildings with some framed replacements

Range of Building Heights:
2-3 Stories

Age:
19th and early 20th century

A4 Example: Xian, China

RE Photo

Figure 277. UTZ A4: attached industrial/storage buildings.

Urban Terrain Zone (UTZ) A5: Attached Commercial Buildings Along Arterial Streets

Urban Terrain Zone A5

Building Function and Density:
Attached commercial buildings along string streets

Building Separation:
Attached

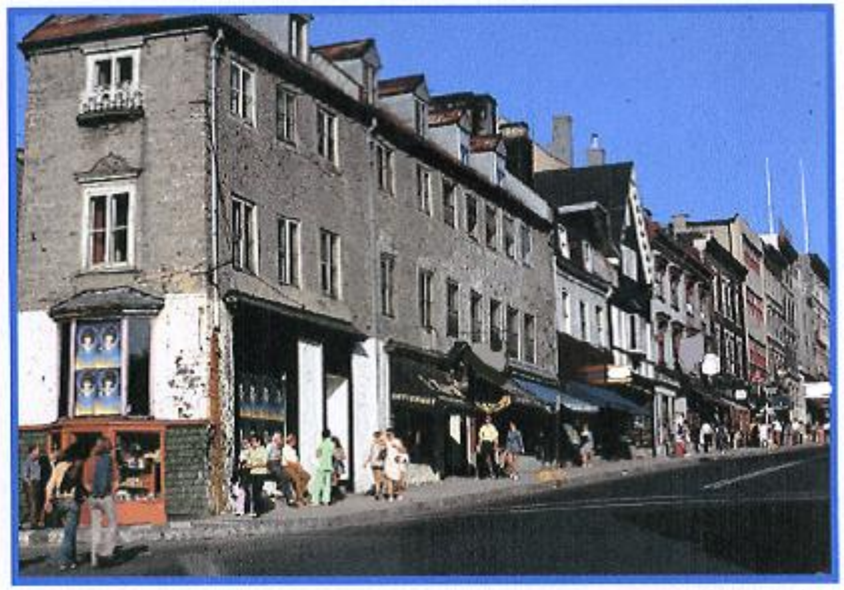
Building Setting:
Usually found near the original core of cities and along major streets outward from center

Building Construction Type:
Mainly brick buildings with some framed replacements

Range of Building Heights:
2-3 Stories

Age:
19th and early 20th century

A5 Example: Quebec City



RE photo

Figure 278. UTZ A5: attached commercial buildings along arterial streets.

Urban Terrain Zone (UTZ) Dc1: Closely spaced High-rise Office Buildings

Urban Terrain Zone Dc1

Building Function and Density:
Detached, closely-spaced office buildings

Building Separation:
Less than 13 meters

Building Setting:
In newly developed areas in central city

Building Construction Type:
Framed light clad

Range of Building Heights:
High-rises, 10 to 50 Stories

Age:
Since 1950

Dc1 Example: Singapore

RE photo 2004

Figure 279. UTZ Dc1: closely spaced high-rise office buildings.

Urban Terrain Zone (UTZ) Dc2: Closely spaced Apartment Buildings

Urban Terrain Zone Dc2

Building Function and Density:
Detached, closely-spaced apartments

Building Separation:
Less than 13 meters

Building Setting:
In the first rings of suburbs outward from central city

Building Construction Type:
Framed light clad or box-wall principle (panel wall) buildings

Range of Building Heights:
5 to 30 Stories

Age:
Mainly since World War II

Dc2 Example: Cairo, Egypt

RE photo 2004

Figure 280. UTZ Dc2: closely spaced apartment buildings.

Urban Terrain Zone (UTZ) Dc3: Closely Spaced Houses

Urban Terrain Zone Dc3

Building Function and Density:
Detached, closely-spaced houses

Building Separation:
Less than 13 meters

Building Setting:
In residential areas both near the center (older) and at city edge (newer)

Building Construction Type:
Framed with various sidings (brick, wood, stucco) and mass brick, CMU, and framed with infill walls

Range of Building Heights:
1 - 3 Stories

Age:
All ages

Dc3 Example: Germany

Figure 281. UTZ Dc3: closely spaced houses.

Urban Terrain Zone (UTZ) Dc4: Closely Spaced Industrial/storage Buildings

Urban Terrain Zone Dc4

Building Function and Density:
Detached, closely spaced industrial/storage buildings

Building Separation:
Less than 13 meters

Building Setting:
At the edge of the city

Building Construction Type:
Brick, CMUs, R/C Framed with Infill walls, and Light Steel framed

Range of Building Heights:
1-4 Stories

Age:
Mainly since World War II

Dc4 Example: England

RE photo, 2004

Figure 282. UTZ Dc4: closely spaced industrial/storage buildings.

Urban Terrain Zone (UTZ) Dc5: Closely Spaced Commercial Buildings

Urban Terrain Zone Dc5

Building Function and Density:
Detached, closely spaced commercial buildings

Building Separation:
Less than 13 meters

Building Setting:
At the edge of the city

Building Construction Type:
Brick, CMUs, R/C Framed with Infill walls, and Light Steel framed

Range of Building Heights:
1-4 Stories

Age:
Mainly since World War II

Dc5 Example: Germany

Figure 283. UTZ Dc5: closely spaced commercial buildings.

Urban Terrain Zone (UTZ) Dc6: Closely Spaced Administrative/Cultural Buildings

Urban Terrain Zone Dc6

Building Function and Density:
Detached, closely spaced administrative/cultural buildings

Building Separation:
Less than 13 meters

Building Setting:
Anywhere in the city

Building Construction Type:
Brick, CMUs, and R/C Framed with Infill walls

Range of Building Heights:
1-4 Stories

Age:
Spanning time

Dc6 Example: Bangkok

RE photo 2004

Figure 284. UTZ Dc6: closely spaced administrative/cultural buildings.

Urban Terrain Zone (UTZ) Do1: Widely spaced Commercial Buildings, Shopping Centers

Urban Terrain Zone Do1

Building Function and Density:
Detached, widely spaced (> 13 meters) commercial buildings, shopping center, malls

Building Separation:
13 meter to 100 meters

Building Setting:
Located in modern, planned developments with large parking lots.

Building Construction Type:
Mass construction: tilt-ups, CMU load-bearing, poured-in-place concrete, and framed with various infill materials

Range of Building Heights:
1-3 Stories

Age: Since about 1960

Do1 Example: U.S.

RE Photo

Figure 285. UTZ Do1: widely spaced commercial buildings, shopping centers.

Urban Terrain Zone (UTZ) Do2: Widely spaced Apartment Buildings

Urban Terrain Zone Do2

Building Function and Density:
Detached, widely spaced (> 13 meters) apartment buildings.

Building Separation:
13 meter to 100 meters

Building Setting:
This type of UTZ demonstrates that its buildings were planned as a cohesive complex with integrated large, public areas for landscaping, recreation, and parking.

Building Construction Type:
Two major types are common: (1) framed, light-clad structures; and (2) mass construction "box-wall principle" (panel type)

Range of Building Heights:
3 - 15 Stories

Age:
Most buildings in Do2 zones have been built since World War II.

Do2 Example: Prague, Czech Republic

RE Photo 2004

Developments of this type were replicated countless times in the Soviet Union and areas under its influence in post World War II times to replace lost housing. Their construction followed state-directed plans expressed in buildings in the five story range (and without elevators). Entrances and stairways served a set of units on each side of each stair complex. Ventilation (see rooftops) was also by sets of units.

Figure 286. UTZ Do2: widely spaced apartment buildings.

Urban Terrain Zone (UTZ) Do3: Widely Spaced Houses

Urban Terrain Zone Do3

Building Function and Density:
Detached, widely spaced houses

Building Separation:
More than 13 meters

Building Setting:
At the edge of the city

Building Construction Type:
R/C Framed with Infill walls, wood framed, and concrete masonry units with veneers

Range of Building Heights:
1-3 Stories

Age:
Mainly since World War II

Do3 Example: Austria

RE photo, 2004

Figure 287. UTZ Do3: widely spaced houses.

Urban Terrain Zone (UTZ) Do4: Widely Spaced Industrial/Storage Buildings

Urban Terrain Zone Do4

Building Function and Density:
Detached, widely spaced industrial/storage buildings

Building Separation:
More than 13 meters

Building Setting:
In areas designated for industrial use, at city edge

Building Construction Type:
R/C framed with light cladding and R/C Framed with Infill walls,

Range of Building Heights:
1-3 Stories

Age:
Mainly since World War II

Do4 Example: Germany

Figure 288. UTZ Do4: widely spaced industrial/storage buildings.

Urban Terrain Zone (UTZ) Do5: Widely Spaced Commercial Buildings

Urban Terrain Zone Do5

Building Function and Density:
Detached, widely spaced commercial buildings

Building Separation:
More than 13 meters

Building Setting:
In new areas, either redeveloped in older sections or in new sections

Building Construction Type:
R/C framed with light cladding and R/C Framed with Infill walls

Range of Building Heights:
3-15 Stories

Age:
Mainly since World War II

Do5 Example: Germany

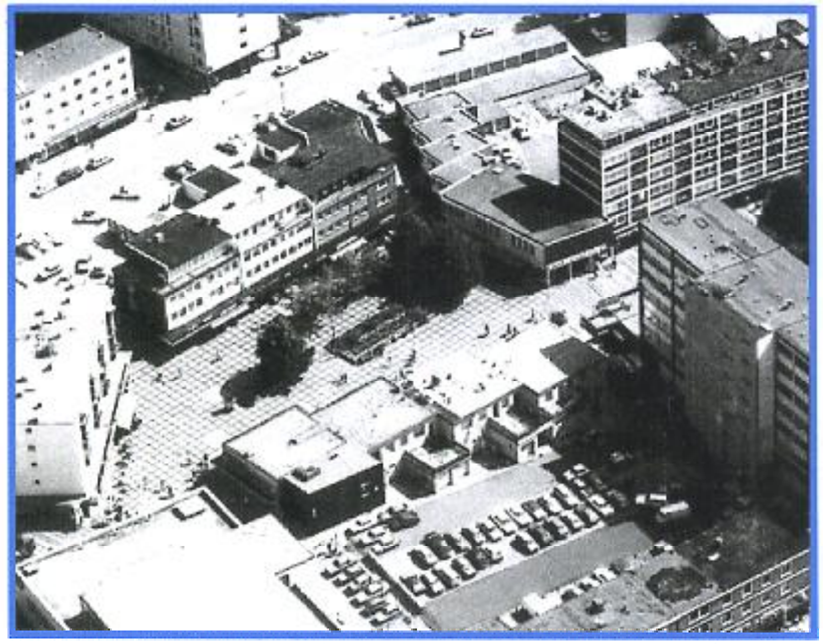


Figure 289. UTZ Do5: widely spaced commercial buildings.

Urban Terrain Zone (UTZ) Do6: Widely Spaced Administrative/Cultural Buildings

Urban Terrain Zone Do6

Building Function and Density:
Detached, widely spaced administrative/cultural buildings

Building Separation:
More than 13 meters

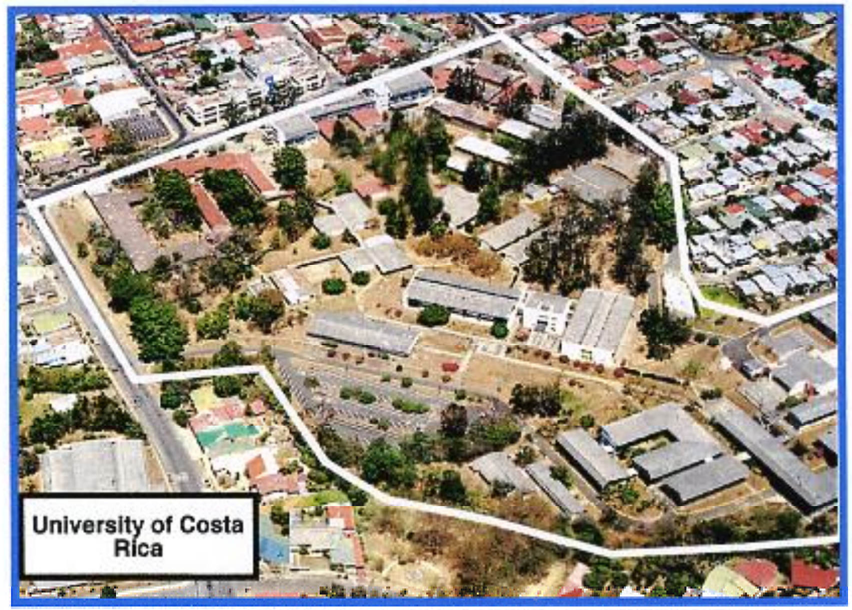
Building Setting:
At various places where a society places a government center, monuments, campuses, religious centers, etc.

Building Construction Type:
Stone, brick, concrete, CMUs, R/C framed with light cladding and R/C Framed with Infill walls

Range of Building Heights:
3-15 Stories

Age:
Spanning time

Do6 Example: Costa Rica



RE Photo

Figure 290. UTZ Do6: widely spaced administrative/cultural buildings.

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Appendix A

Global Set, Buildings with Venting as a proportion of Front Walls: Mass Construction Buildings

Note: all photographs by R. Ellefsen, unless otherwise indicated

Stone Houses: Venting

Stone House (Mass 1)

Windows 12.5 %
Doors 2.6 %
Combined 15.1 %

House located in Edinburgh, Scotland. Windows have wooden frames and sashes with small panes.

Photo: 1994

Stone House (Mass 1)

Windows 5.6 %
Doors obscured

House located near Limoge, France in a *Bastide* town. Windows have wooden frames and sashes with small panes.

Photo: 1991

Stone House (Mass 1)

Windows 5.9 %
Doors 2.2 %
Combined 8.1 %

House is located in Hammelburg, Germany. Windows have wooden frames and sashes with small panes.

Photo: 1980

Stone House (Mass 1)

Windows 4.6 %
Doors 4.5 %
Combined 9.1 %

House located in Castellina, Tuscany, Italy. Structure shows indications of having been modified several times.

Photo: 2004

Stone House (Mass 1)

Windows 6.9 %
Doors not visible

House located in Salzgitter, Germany. Vertically aligned windows have arched reinforcement wooden frames, small panes.

Photo 1980

Stone House (Mass 1)

Windows 11.4 %
Doors.8 %
Combined 12.2 %

Manor House located in Wilton, England. Windows have wooden frames and sashes with small panes.

Photo: 1993

Adobe House: Venting

Adobe House (Mass 3)

Windows 6.5 %
Doors 5.8 %
Combined 12.3 %

House located in Luxor, Egypt.

Photo: 2004

Brick Houses: Venting

Brick House (Mass 5)

Windows 14.1 %
Doors 2.8 %
Combined 16.9 %

House, located in Koblenz, Germany is a duplex, one unit on floor one and two plus a small apartment in the attic.

Photo: 2004 by Dave Fordyce, ARL

Brick House (Mass 5)

Windows 9.6 %
Door 5.3 %
Combined 14.9 %

House located in Elburz Mountains near Caspian Sea.

Photo: 1967

Brick House (Mass 5)

Windows 17.9 %
Door 2.8 %
Combined 20.7 %

House located in Uppsala, Sweden. House has classical vertical alignment of windows.

Photo: 1992

Brick House (Mass 5)

Windows 15.3 %
Door 3.4 %
Combined 18.7 %

House in Bremen, Germany. Note uniform windows.

Photo: 1999

Brick House (Mass 5)

Windows 22.3 %
Door not visible

House in Bremen, Germany. Arches over basement windows reveal brick construction.

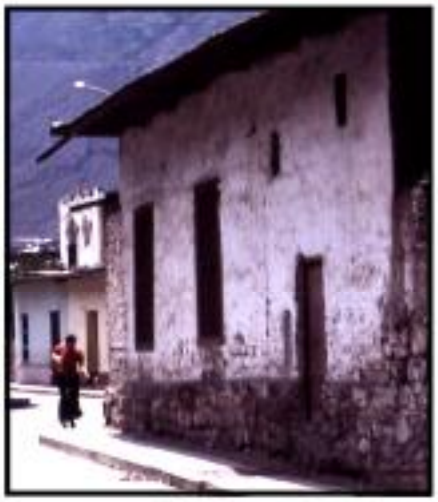
Photo: 1999

Brick House (Mass 5)

Windows 13.6 %
Doors 2.6 %
Combined 16.2 %

House in Juarez, Chihuahua, Mexico

Photo: 1999



Brick House (Mass 5)

Windows 7.4 %
Doors 4.6 %
Combined 12.0 %

House in Andean village, Peru

Photo: 1980

Brick House (Mass 5)

Windows 15.4 %
Doors not visible

House in a North China village, near Xian

Photo: 1997

Brick House (Mass 5)

Windows 12.8 %
Door 9.2 %
Combined 15.8 %

House converted to a store in San Jose, Costa Rica. “Dog House” dormer on rusted corrugated steel roof has a swinging sash window.

Photo: 1994

Brick House (Mass 7)

Windows 15.5 %
Door 4.8 %
Combined 20.3 %

House is in Baltimore, MD, USA. Note vertical window alignment, wooden sashes and frames, and small panes.

Photo: 1988

Brick House (Mass 5)

Windows 10.2 %
Door 2.6 %
Combined 12.8 %

House in Norrokoping, Sweden.

Photo: 1992

Brick House (Mass 5)

Windows 12.5 %
Door 3.3 %
Combined 15.8 %

House in Bremen, Germany. Note French doors. Frames and sashes are wooden.

Photo: 1999

Brick Row House (Mass 7)

Windows 12.3 %
Doors 6.1 %
Combined 18.4 %

Building is in Vienna, Austria. It has a door for each set of five apartments.

Photo: 2004

Brick Row House (Mass 7)

Windows 16.5 %
Doors 6.3 %
Combined 22.8 %

Building is in Bremen, Germany. Door and windows have wood frames.

Photo: 1999

Brick Row House (Mass 7)

Windows 5.4 %
Doors 1.3 %
Combined 6.7 %

Building is in Lebenstedt, Salzgitter, Germany. It is part of a development built in the 1930s to house steel workers.

Photo: 1982

Brick Row House (Mass 7)

Windows 12.3 %
Doors 9.0 %
Combined 21.3 %

Building is in Wilton, England. It is typical of factory workers' housing in the nineteenth century.

Photo: 1993

Brick Row House (Mass 7)

Windows 14.7 %
Doors 12.6 %
Combined 27.3 %

Building is near Guilin, China

Photo: 1996

Brick Row House (Mass 7)

Windows 11.4 %
Doors 4.3 %
Combined 15.7 %

Building is in Stratford, England, another typical English row house.

Photo: 1993

CMU House (Mass 14)

Windows 12.2 %
Door 2.3 %
Combined 14.5 %

Building is in Bremen, Germany. It is being constructed as a replacement for a brick house

Photo: 1999

CMU House (MASS 14)

Windows: 15.3 %
Doors 2.7 %
Combined 18.0 %

Building is in Lebenstadt, Salzgitter, Germany. CMUs are light-weight foamed concrete.

Photo: 1982

CMU House (Mass 14)

Windows 9.1 %
Doors 3.8 %
Combined 12.9 %

House is in Puntarenas, Costa Rica. CMUs are covered with stucco in front.

Photo: 1982

CMU House (Mass 14)

Windows 11.1 %
Door not visible

Building is in Salzgitter, Germany. Blocks are typical, in Germany, large dimension foam.

Photo: 1982

CMU House (Mass 14)

Windows 9.2 %
Doors 4.1 %
Combined 13.3 %

House in Puntarenas, Costa Rica

Photo: 1980

CMU House (Mass 14)

Windows 3.9 %
Doors 6.3 %
Combined 10.2 %

House is in Lima, Peru, built on the slopes of the Andes in the eastern part of the city.

Photo: 1980

Brick Apartment Buildings: Venting

Brick Apartment Building (Mass 8)

Windows 11.6 %
Doors 9.8 %
Combined 21.4 %

Building in Budapest, Hungary. Apartments on upper floor undergoing renovation. Entry doorway into a corridor is made of wood

Photo: 2004

Brick Apartment Building (Mass 8)

Windows 13.6 %
Doors 3.7 %
Combined 17.3 %

Building is in Koblenz, Germany. Classic windows are center open topped by a single pane.

Photo by Dave Fordyce, ARL, 2004

Brick Apartment Building (Mass 8)

Windows 11.6 %
Doors 2.1 %
Combined 13.7 %

Building in Uppsala, Sweden. Apartments occupy upper floors, retail store on ground floor.

Photo: 1992

Brick Apartment Building (Mass 8)

Windows 13.1 %
Doors 1.4 %
Combined 14.5 %

Building is in Koblenz, Germany Windows follow classic style.

Photo by Dave Fordyce, ARL, 2004

Brick Apartment Building (Mass 8)

Windows 13.9 %
Doors 2.1 %
Combined 16.0 %

Building is in Koblenz, Germany

Photo by Dave Fordyce, ARL, 2004

Brick Apartment Building (Mass 8)

Windows 16.8 %
Doors 3.4 %
Combined 20.2 %

Building in Rome, Italy. Vertically aligned windows help identify the building as having brick construction.

Photo: 1993

Brick Apartment Building (Mass 8)

Windows 16.9 %
Door 3.6 %
Combined 20.5 %

Building is in Bath, England. Windows are longer and narrower than those found on the continent.

Photo: 1993

Brick Apartment Building (Mass 8)

Windows 10.4 %
Door 6.2 %
Combined 16.6 %

Building is in Mumbai (Bombay), India.

Photo: 1967

Brick Apartment Building (Mass 8)

Windows 10.4 %
Door 5.4 %
Combined 15.8 %

Building in Linz, Austria. Baroque decorations don’t disguise the standard window types.

Photo: 1991

Box Wall Principle Apartment Buildings

Box Wall Principle Apartment Building (Mass 22)

Windows 13.7 %
Doors 5.5 %
Combined 19.2 %

Building in Prague, Czech Republic. Structure is a typical Soviet style building.

Photo: 2004

Box Wall Apartment Building (Mass 22)

Windows 23.5 %

Building in East Berlin, Germany

Photo 1980

Box Wall Apartment Building (Mass 22)

Windows 28.3 %

Building in East Berlin, Germany. Each apartment unit has a veranda. Windows and door occupy most of one end of the "box."

Photo: 1980

Box Wall Apartment Building (Mass 22)

Windows 26.7 %

Building in West Berlin. Apartment units have large windows for the daytime occupancy rooms and small windows for bedrooms.

Photo: 1980

Box Wall Apartment Building (Mass 22)

Windows 34.3 %

Building in Philadelphia, PA, USA. Each cell has large windows and a door entry to the veranda.

Photo: 1985

Box Wall Apartment Building (Mass 22)

Windows 18.8 %

Building in Braunschweig, Germany.

Photo: 1983

Brick Hotels: Venting

Brick Hotel (Mass 9)

Windows 16.3 %
Doors 2.8 %
Combined 19.1 %

Building is in Vienna, Austria. Windows on upper three floors measure one by one and a half meters.

Photo: 2004

Brick Hotel (Mass 9)

Windows 18.4 %
Doors 3.4 %
Combined 21.8 %

Building is in Reims, France. Note lack of windows at strong corner of this brick structure, in accordance with basic theory. Building has a Mansard roof, a device to reduce taxes based on a full floor.

Photo: 1993

Brick Hotel (Mass 9)

Windows 15.1 %
Doors 2.6 %
Combined 17.7 %

Each of the upper floor windows serves but a single room, indicating rather common narrow guest rooms in hotels of this class.

Photo: 1999

Brick Hotel (Mass 9)

Windows 12.4 %
Doors 3.3 %
Combined 15.7 %

Building is in Falkenberg, Germany. Windows are variations of the European standard.

Photo: 1983

Brick Hotel (Mass 9)

Windows 22.1 %
Doors 5.3 %
Combined 27.4 %

Building is in Helsingborg, Sweden. Note brick arches over windows to replace wall's lost integrity.

Photo: 1983

Brick Office Buildings: Venting

Brick Office Building (Mass 10)

Windows 14.3 %
Doors 2.3 %
Combined 16.6 %

Building is in Helsinki, Finland in the Empire style.

Photo: 1976

Brick Office Building (Mass 10)

Windows 19.2 %
Doors 4.5 %
Combined 23.7 %

Building, a government office building, is in Vienna, Austria.

Photo: 2004

Brick Office Building (Mass 10)

Window 11.6 %
Doors 4.9 %
Combined 16.5 %

Building, a remnant of British colonial days, is in Singapore.

Photo: 2004

Brick Office Building (Mass 10)

Windows 16.9 %
Doors 3.4 %
Combined 20.3 %

Building is in Bremen, Germany

Photo: 1999

Brick Office Building (Mass 10)

Windows 12.3 %
Doors 3.7 %
Combined 16.0 %

Building is in Lima, Peru

Photo: 1980

Brick Office Building **(Mass 10)**

Windows 20.5 %
Door 1.9 %
Combined 22.4 %

Building is in Uppsala, Sweden

Photo: 1993

Brick Office Building (Mass 10)

Windows 16.8 %
Doors 2.8 %
Combined 19.6 %

Building is in Wellington, New Zealand. Note: windows are narrower than those in German buildings.

Photo: 1995

Brick Office Building **(Mass 10)**

Windows 9.9 %

Building is in Koblenz, Germany

Photo by Dave Fordyce, ARL 2004

Brick Office Building (Mass 10)

Windows 13.4 %
Doors 1.3 %
Combined 14.7 %

Building, a government office, is in Bath, England

Photo: 1992

Masonry Industrial/storage Buildings: Venting

Brick Industrial/storage Building (Mass 13)

Windows 22.1 %
Doors 0.7 %
Combined 22.8 %

Building is in Norrokoping, Sweden. Note arches over windows and joist-end plates in walls

Photo 1995

Brick Industrial/storage Building (Mass 13)

Windows 17.4 %

Building, in Shanghai, is concrete, note pilasters. Uses open windows for ventilation

Photo: 1996

Brick Industrial/storage Building (Mass 13)

Windows 16.8 %

Building is in Stavanger, Norway. Note arches over windows and small panes

Photo: 1976

Brick Industrial/storage Building (Mass 13)

Windows 27.4 %
Doors 1.7 %
Combined 29.1 %

Building is in Helsinki, Finland

Photo: 1976

Brick Industrial/Storage Building (Mass 13)

Windows 6.4 %
Doors 7.9 %
Combined 14.3 %

Building is in Singapore, an old “godown,” remnant of British days (probably no longer standing)

Photo: 1984

Large Masonry Buildings, Churches and Mosques

Mosque (Mass 12)

Windows 11.8 %
Doors 4.4 %
Combined 16.2 %

Friday Mosque in Delhi, India

Photo: 1967

Temple (Mass 12)

Windows 6.7 %
Doors 2.4 %
Combined 9.1 %

Building is in Bangkok, Thailand

Photo: 2004

Islamic Religious Building (Mass 12)

Windows 5.4 %
Doors 6.1 %
Combined 11.5 %

Building is in Chinai (Madras), India, an example of the propagation of Islamic Architecture to the southern end of the Indian sub-continent.

Photo: 1967

Mosque (Mass 12)

Windows 1.6 %
Doors 6.8 %
Combined 8.4 %

Building is in Teheran, Iran. The small proportion of venting is typical.

Photo: 1967

Church (Mass 2)

Windows 17.2 %
Doors 1.8 %
Combined 19.0 %

Building is in Strasbourg, France. Windows do not provide air circulation.

Photo: 2002

Church (Mass 12)

Windows 4.6 %
Doors 1.6 %
Combined 6.2 %

Building is a Roman Catholic Church in Heredia, Costa Rica

Photo: 1994

Church (Mass 2)

Windows 14.1 %
Doors 4.5 %
Combined 18.6 %

Building is a Church of England cathedral in Canterbury, England

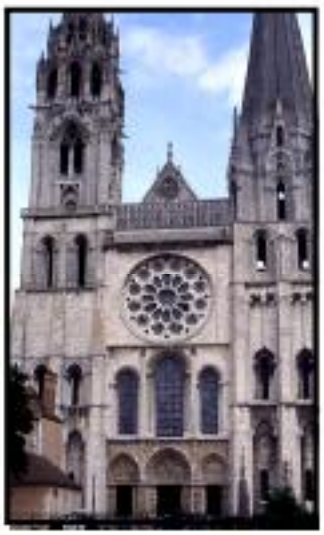
Photo: 1993

Church (Mass 2)

Windows 7.1 %
Doors 1.3 %
Combined 8.4 %

Church is in Koblenz, Germany

Photo by Dave Fordyce, ARL, 2004



Church (Mass 2)

Windows 8.3 %
Doors 1.9 %
Combined 10.2 %

Building is a cathedral in Chartes, France, known for its stained glass windows.

Photo: 1995

Church (Mass 2)

Windows 19.1 %

Building is a cathedral in Paris, known for its flying buttresses to support its tall, narrow structure.

Photo: 1995

Church (Mass 12)

Windows 10.2 %
Doors 3.1 %
Combined 13.3 %

Building is a Roman Catholic church on St. Thomas Mount in southern Chenai (Madras), India

Photo: 1958

Religious Building (Mass 2)

Windows 2.6 %
Doors 2.2 %
Combined 4.8 %

This stone structure is in Jerusalem, Israel

Photo: 1983

Framed Construction Buildings

Wood Framed Houses: Venting

Wood Framed House (Framed 3)

Windows 11.2 %
Doors 3.1 %
Combined 14.3 %

House is in Stavanger, Norway

Photo: 1976

Wood Framed House (Framed 3)

Windows 7.8 %

Building is in Kuala Lumpur, Malaysia
Photo: 1984

Wood Framed House (Framed 3)

Windows 9.5 %
Doors 3.8 %
Combined 13.3 %
Building is in Imeln, Sweden
Photo: 1983

Wood Framed House (Framed 3)

Windows 7.9 %

Building in Helsinki, Finland is of a traditional style

Photo: 1983

Framed, Curtain Wall Apartment: Venting (Framed 8)

Windows 17.6 %

Building is in Macao. Larger windows are for daytime occupancy, smaller ones for bedrooms and kitchens.

Photo: 1997

Framed, Curtain Wall Apartment: Venting (Framed 8)

Windows 13.3 %

Building is in Lisbon, Portugal. Window size varies, as in above photo.

Photo: 1991

Framed, Curtain Wall Apartment: Venting (Framed 8)

Windows 24.7 %
Doors 8.3 %
Combined 33.0 %

Building is in London, England

Photo: 1991

Framed, Curtain Wall Apartment: Venting (Framed 8)

Windows 39.4 %

Building is in Rotterdam, Netherlands

Photo by Glenn Schumacher, 1980

Framed, Curtain Wall Apartment: (Framed 8)

Windows 39.4 %

Building is in Panama City, Panama

Aluminum frames separate large panes in each module.

Photo: 1999

Framed, Curtain Wall Apartment: (Framed 8)

Windows 34.1 %

Building is in Hong Kong. Each apartment unit is fully vented at its outside wall.

Photo: 1983

Framed Heavy Clad Hotels: Venting

Framed, Heavy Clad Hotel (Framed 6)

Windows 20.4 %

Building is in Denver, Colorado

Each guest room has a window.

Photo: 1996

Framed, Heavy Clad Hotel (Framed 6)

Windows 16.2 %
Doors 4.7 %
Combined 20.9 %

Building is in Tunis, Tunisia, classic hotel from French colonial days

Photo: 1984

Framed, Heavy Clad Hotel (Framed 6)

Windows 18.8 %
Doors 1.9 %
Combined 20.7 %

Building is in Ho Chi Minh City (then Saigon). Shutters in windows are typical in tropical areas.

Photo: 1958

Framed, Heavy Clad Hotel (Framed 6)

Windows 12.1 %
Doors 1.4 %
Combined 13.5 %

Building is in San Jose, Costa Rica. Windows use wooden sashes.

Photo: 1994

Framed, Heavy Clad Hotel (Framed 6)

Windows 17.4 %
Doors 1.4 %
Combined 18.8 %

Building is in Singapore, the famous Raffles

Photo 2004

Framed Heavy Clad Hotel (Framed 6)

Windows 30.9 %
Doors 1.1 %
Combined 32.0 %

Building is in Hong Kong

Photo: 2004

Framed Heavy Clad Hotel (Framed 6)

Windows 14.9 %
Doors 3.4 %
Combined 18.3 %

Building is in Tokyo, Japan. Its replacement is a framed, light clad structure with larger windows.

Photo: 1984

Framed Heavy Clad Hotel (Framed 6)

Windows 12.4 %
Doors 1.6 %
Combined 14.0 %

Building is in Paris, France

Photo 1992

Framed Heavy Clad Hotel (Framed 6)

Windows 21.8 %

Building is in Colombo, Sri Lanka. Smallish windows are similar to those seen in Brick hotels.

Photo: 2004

Framed Light Clad Apartments with Infill Windows

Framed Light Clad Apartment with Infill Windows (Framed 8)

Windows 15.6 %
Doors 3.3 %
Combined 18.9 %

Building is in San Jose, Costa Rica

Photo: 1994

Framed Light Clad Apartment with Infill Windows (Framed 8)

Windows 12.4 %
Doors 3.4 %
Combined 15.8 %

Building is in New Delhi, India. Window setback provides valuable shade

Photo: 1967

Framed Light Clad Apartment with Infill Windows (Framed 8)

Windows 21.5 %
Doors 6.1 %
Combined 27.6 %

Building is in Guilin, China

Photo: 1997

Framed Light Clad Apartment with Infill Windows (Framed 8)

Windows 19.9 %

Building is in Cairo, Egypt

Photo: 2004

Framed Light Clad Apartment with Infill Windows (Framed 8)

Windows 9.9 %
Doors 2.2 %
Combined 12.1 %

Building is in Tel Aviv, Israel

Photo: 1999

Framed Light Clad Apartment with Infill Windows (Framed 8)

Windows 14.6 %

Building in Gibraltar

Photo: 1991

Framed Light Clad Curtain Wall Hotels: Venting

Light Clad Curtain Wall Hotel (Framed 9)

Windows 13.3 %
Door 2.0 %
Combined 15.3 %

Building is in Uppsala, Sweden. Small size of rooms are apparent from the window spacing. Windows tilt vertically to open.

Photo: 1992

Light Clad Curtain Wall Hotel (Framed 9)

Windows 10.7 %

Building in California

Photo: 1989

Light Clad Curtain Wall Hotel (Framed 9)

Windows 44.2 %

Building is in Macao (now China). Windows occupy most of end wall of each guest room.

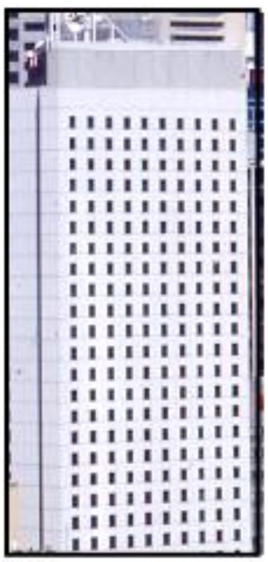
Photo: 1996

Light Clad Curtain Wall Hotel (Framed 9)

Windows 23.8 %

Building is in Edmonton, Alberta, Canada. Mullions separate windows.

Photo: 1982



Light Clad Curtain Wall Hotel (Framed 9)

Windows 14.3 %

Building is in Sydney, New South Wales, Australia. Window style falls into the class of "minimum."

Photo: 1992

Light Clad Curtain Wall Hotel (Framed 9)

Windows 24.4 %

Building is in Shanghai, China.

Photo: 1996

Framed Light Clad Infill Wall Hotel: Venting

Light Clad Infill Wall Hotel (Framed 9)

Windows 33.2 %

Building is in Bangkok, Thailand. Sliding glass window/door provides access to deck for each guest room.

Photo: 2004

Light Clad Infill Wall Hotel (Framed 9)

Windows 15.9 %

Building is in Singapore. Again, note window-glass window/door for entry onto deck.

Photo: 2004

Light Clad Infill Wall Hotel (Framed 9)

Windows 35.3 %
Doors 2.6 %
Combined 37.9 %

Building is in Guilin, China. Note mullions separating guest rooms.

Photo: 1996

Framed Light Clad Curtain Wall Office Building: Venting

Light Clad Curtain Wall Office Building (Framed 10)

Windows: 50.0%

Building is in Bangkok, Thailand. Open tilting windows suggest either building has no air conditioning or occupants choose not to use it.

Photo: 1983

Light Clad Curtain Wall Office Building (Framed 10)

Windows 42.4 %
Doors 1.4 %
Combined 43.8 %

Building is in Stavanger, Norway. Windows are in a spandrel pattern.

Photo: 1976

Light Clad Curtain Wall Office Building (Framed 10)

Windows 32.2 %

Building is in Manila, Philippines. Spandrel pattern is seen again.

Photo: 1981

Light Clad Curtain Wall Office Building (Framed 10)

Windows 16.3 %

Building is in Uppsala, Sweden

Photo: 1994

Light Clad Curtain Wall Office Building (Framed 10)

Windows 28.4 %

Building is in Haifa, Israel. Spandrels.

Photo: 1999

Light Clad Curtain Wall Office Building (Framed 10)

Windows 56.7 %
Doors 2.7 %
Combined 59.4 %

Building in Tel Aviv, Israel. Photo: 1999

Light Clad Curtain Wall Office Building (Framed 10)

Windows 28.5 %
Doors 3.7 %
Combined 32.3 %

Building is in Prague, Czech Republic.

Photo: 2004

Light Clad Curtain Wall Office Building (Framed 10)

Windows 56.3 %
Doors 1.5 %
Combined 57.8 %

Building is in Koblenz, Germany

Photo by Dave Fordyce, ARL, 2004

Light Clad Curtain Wall Office Building (Framed 10)

Windows 58.8 %

Building is in Hong Kong. Another example of the popular spandrel type of window pattern.

Photo: 2004

Framed Light Clad Infill Wall Office Building: Venting

Light Clad Infill Wall Office (Framed 10)
Windows 28.3 %
Doors 1.7 %
Combined 30.3 %
Building in Lima, Peru
Photo: 1980

Light Clad Infill Wall Office (Framed 10)

Windows 17.2 %
Doors 2.8 %
Combined 20.0 %

Building is in Manila, Philippines. Note again the provision of shade for tropical area buildings.

Photo: 1981

Light Clad Infill Wall Office (Framed 10)

Windows 25.9 %

Building is in Salzgitter, Germany. Tilt windows are seen.

Photo: 1999

Light Clad Infill Wall Office (Framed 10)

Windows 17.7 %
Doors 1.9 %
Combined 19.6 %

Building is in Chenai (Madras), India.

Photo: 1967

Light Clad Infill Wall Office (Framed 10)

Windows 34.9 %

Building is in Salzgitter, Germany. Visible partitions as seen through windows reveal different size office units.

Photo: 1999

Light Clad Infill Wall Office (Framed 10)

Windows 11.3 %
Doors 1.3 %
Combined 12.6 %

Building is in San Jose, Costa Rica. Again, smallish windows are seen in a tropical environment.

Photo: 1994

Light Steel Framed Industrial/Storage Buildings: Venting

Steel Framed I/S Building (Framed 20)

Windows 5.2 %
Doors 8.7 %
Combined 13.9 %
Building in Bangkok, Thailand. Photo 2004

Steel Framed I/S Building (Framed 20)

Windows 4.1 %
Open end.
Building in Tokyo, Japan.

Photo 1967

Steel Framed Industrial/storage Building (Framed 20)

Windows 5.1 %

Building is in Salzgitter, Germany

Minimum lighting but maximum security afforded by small windows.

Photo: 1983

Steel Framed Industrial/Storage Building (Framed 20)

Windows 7.2 %

Building is in Switzerland, near Zurich

Photo: 2004

Steel Framed Industrial/Storage Building (Framed 20)

Windows 2.1 %
Doors 20.4 %
Combined 22.5 %

Building is in Uppsala, Sweden

Photo: 1992

Steel Framed Industrial/Storage Building (Framed 20)

Windows 2.9 %

Building is in Uppsala, Sweden

Photo: 1992

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Glossary

Ashlar Stone a thin slab of squared stone, used for facing or building

Balloon frame construction involves the employment of small dimension studs set closely together (16 inch centers in the U.S.) to form the support for a wall

Box-wall (aka panel) construction construction of a building using walls and floor/ceilings to form five sides of a "box," used commonly for hotels and apartments where room size is designed to remain stationary

Brick veneer where only stretchers are exposed on a wall and the bricks cover either a mass construction wall or are used as sheathing over a framed wall

Brick wall width terminology double brick refers to a brick wall the length of two headers (some 8" in the U.S., and 12 cm abroad); triple brick refers to a thickness equivalent of three headers, plus mortar; quadruple brick refers to a thickness equivalent of four headers, plus mortar, and so on with each brick increment

Capital The ornamental top of stone column, also applied to the decorated top floor of a classic styled building, either masonry or framed heavy-clad

Cladding The material covering the frame of either a steel heavy-clad structure or a steel or reinforced concrete frame light-clad structure

CMU A concrete masonry unit, commonly referred to as a concrete block, or cinder block (even when the material is concrete and does not contain any light-weight volcanic [cinder] material) Sizes vary internationally but the dimensions used in this report are 40 cm long by 20 centimeters deep and 20 centimeters tall

Corbel A bracket of stone, wood, brick, or other building material, projecting from the face of a wall and generally used to support a cornice, an arch, or a beam or concrete floor

Dowel A usually round pin that fits tightly into a corresponding hole to fasten or align two adjacent pieces

English Bond A form of laying brick where rows of headers alternate with rows of stretchers

Flemish Bond A form of laying brick where a header and a stretcher are alternated

Framed Construction Use of wood, steel, reinforced concrete columns and beams to support loads

Grout Various cement-based materials poured around rebar in cavities in concrete masonry units to provide strength and to tie CMU's together

Half-timbered Construction Where braced squared wooden columns and beams support a structure, and where wattle and daub and other materials are used as infill

Header The end of a single brick

Heavy cladding Where a combination of materials — terra cotta, stiffening, and brick or stone — cover a steel framed structure with the purpose of protection against the elements, stiffening of the frame, and giving the appearance of a masonry structure

Infill Non load-bearing material placed between columns and beams, and floor-ceilings, in a framed structure, to protect from the elements (see cover photo example)

Light cladding Involves use of a variety of light-weight, and thin, materials to cover either a steel framed structure or a steel-reinforced concrete framed structure; material may be glass, metal, a composite, lightweight foamed concrete, or a thin sheet of stone

Lintel A horizontal beam placed above a door or window in a mass construction building to support the load above, and to replace the wall integrity that has been lost by removing some of it for the window or door

Mass Construction Use of stone, brick (kiln-dried or sun dried), structural grade terra cotta, poured-in-place or panel concrete walls, or even wood in a solid log structure, where the walls of a structure are load-bearing thus supporting dead loads and live loads

Mortar A mixture of cement or lime mixed with sand and water that is used in building

Mortise A cavity, usually rectangular, in a piece of wood, stone, or other material, prepared to receive a similarly shaped projection or tenon of another piece, to hold the two together

Mud Bricks Blocks made of a local clay in a mod and strengthened with a variety of materials, usually straw, and then cured in the sun. Sizes are larger than kiln-dried bricks, often about 30 by 15 by 5 centimeters

Pediment Literally the foot, or base of a classic Greek column. The term is used here to refer to the ornamented ground floor of a Framed Heavy-clad structure, one that is taller (to about 7 meters) than the upper floors (at about 3 meters each)

Perimeter Foundation A mass construction base for a structure, made of either reinforced concrete or stone upon which other building material is constructed

Pilaster A column set into a wall to add strength and stability; pilasters are commonly employed with poured-in-place concrete walls

Pinons Shaped ends of a wooden beam inserted into a mortise, and connected with dowels

Platform Framed Construction Similar to Balloon Framed construction but employing a platform floor at each floor level, rather than having columns extend the full height of the structure

Plinth A solid pedestal foundation or base on which to rest a wall

Post and Beam Wood Construction As with half-timbered structures, walls are supported by fairly wide-spaced columns, tied to the foundation and to beams. Columns are larger in dimension than those used in balloon construction and are placed farther apart. Many older wooden structures in the U.S. and abroad have used this method of construction.

Purlin One of several horizontal members supporting the rafters of a roof

Rebar Steel rods placed in concrete to provide strength and to prevent failure in the event of breakage of the concrete; sizes and density vary with need

Reinforced concrete The abbreviation R/C is used in this report; reinforcement is achieved either with rebar or steel mesh (in the case of walls or floor/ceilings)

Rubble Stone Irregularly placed stones formed into a wall with varying amounts of mortar poured among them

Running Bond A type of laying bricks in a wall where a row of headers is exposed at the outer surface of the wall every fifth or sixth course

Shaft The main part of a classic columns (between pediment and capital) and also used to refer to the many floors of a framed heavy-clad building lying between the pediment floor, at ground level, and the capital floor

Sheathing A layer of boards or of other wood or fiber materials applied to the outer studs, joists, and rafters of a building to strengthen the structure and serve as a base for an exterior weatherproof cladding

Soldier A brick laid in a vertical position in a wall

Stretcher The length of a brick

Stucco A durable finish for exterior walls, applied wet and usually composed of cement, sand, or lime

Terra Cotta A hard, semi-fired, waterproof ceramic tile used in building construction

Tilt-up Construction Where the walls of a building are eigher poured on the structure's floor or delivered from off-site and then "tilted up" into a vertical position, and then diagonally braced temporarily by steel poles prior to being anchored by rafters and roof

Venting Refers to both windows and doors of a building

Wattle and Daub Wattle refers to poles intertwined with twigs, reeds, or branches for use as walls: daub refers to the mud mix that covers the wattle wall

Wythe One masonry unit thick

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